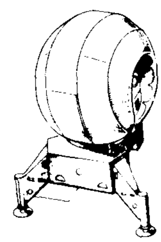

LESSON 4. TRACK RADAR SYSTEMS

MMS Subcourse No 150 .... **Nike Radars and Computer**

Lesson Objective .... **To give you a general knowledge of the purpose, capabilities, and basic function of major units of the target tracking and missile tracking radars and the radar test set on a block diagram level.**

Credit Hours .... **Four**

TEXT

SECTION I. TARGET TRACKING RADAR (TTR).

1. **PURPOSE.** The purpose of the TTR, as illustrated in figure 1A, B, and C, is to supply continuous target position data (slant range D_T, azimuth A_T, and elevation E_T) to the computer.

2. **CAPABILITIES.** The TTR uses the designated target position data (supplied by whichever acquisition radar is in use) to automatically slew the target track antenna to the range and azimuth of the target. The operator, using manual antenna controls, searches for the target in elevation. The TTR tracks the target, supplying accurate elevation, azimuth, and slant range data to the computer system in the trailer mounted director station. The TTR system is synchronized with the selection acquisition radar system to permit simultaneous display of acquisition and target track information and to permit rapid transfer of the target position data to the TTR system. Transfer of target azimuth and range data is accomplished by automatic antenna azimuth and range slewing after operating the DESIGNATE switch in the battery control van and the ACQUIRE switch in the radar control van. Provision is made for manual, aided, or automatic tracking of the target in azimuth and elevation. Four modes of target tracking in range are provided: manual, acquisition aid, track aid, and automatic. Once acquired, the TTR system continues to track the target and supply the computer with position data until the target is abandoned.

3. **MAJOR SYSTEMS.** The TTR is divided into eight major systems, each of which accomplishes one or more of the major functions that contribute to the overall operation of the radar. The functional block diagram (fig 2) depicts the eight major systems of the TTR which are: synchronizing system, transmitting system, RF (monopulse duplexer) and antenna system, receiver system, ranging system, antenna position system, presentation system, and RF and IF testing system. A brief description of each system is given below.

a. **Synchronizing system.** The synchronizing system provides pulses that synchronize units of the TTR system. The "acquiring" of a target is a combined function of the acquisition radar system and the TTR and target ranging radar (TRR) systems; therefore, triggering the synchronizing system with the acquisition preknock pulse from the acquisition synchronizing system synchronizes the transmitter, range, and presentation systems of the TTR and TRR with the acquisition radar system. The synchronizing system (fig 2) provides a target preknock pulse (TPK), a target sync

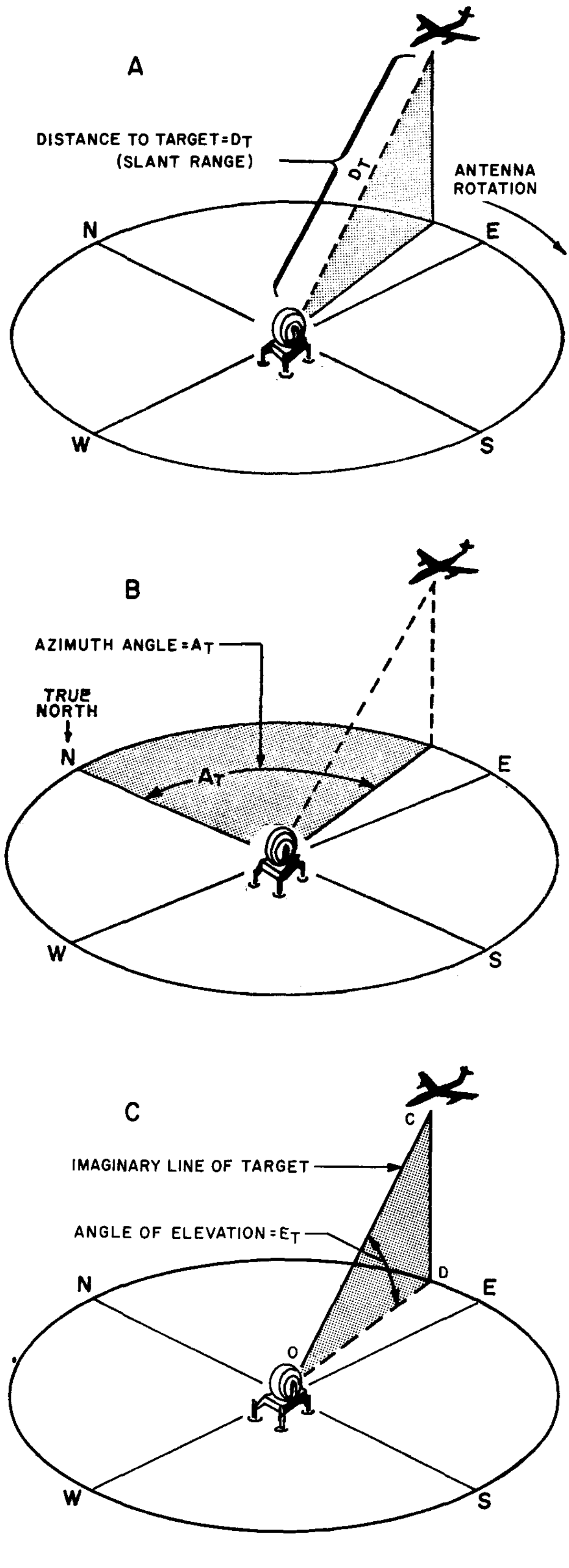

Figure 1. Target coordinates supplied to the computer by TTR.

pulse, and a transmitter sync pulse to the TTR system. The target preknock pulse occurs simultaneously with the acquisition preknock pulse and is applied to the TTR ranging system, the TTR presentation system, the RF and IF test system, and the TRR synchronizing system. The preknock pulse also synchronizes the radar test set with the TTR system. The target sync pulse is applied to the TTR presentation system and to the acquisition marker circuits. The transmitter sync pulse triggers the TTR transmitter system at the PRF of LOPAR or HIPAR, depending upon which acquisition radar is selected. The transmitter sync pulse is developed after the preknock pulse by a time delay which varies depending on whether short-pulse or long-pulse operation of the TTR is selected. This time delay insures stabilization of the range and sweep circuits before the transmitter is triggered.

b. **Transmitter system.** The transmitter system (fig 2), triggered by transmitter sync, produces high power RF pulses at a frequency variable within the X-band. The RF pulses are coupled through the target track monopulse duplexer to the track antenna reflector assembly which beams the RF pulses into space. The long or short pulse mode of operation of the synchronizing system determines duration of the transmitted RF pulses.

c. **RF (monopulse duplexer) and antenna system.** The purpose of this system is to radiate the high power RF energy, generated in the transmitting system, into space and to receive the energy that is reflected when a target intercepts the RF beam. In most tracking radars, lobe switching or conical scanning is used to obtain target position information, and several pulses must be used to determine target azimuth and elevation. However, in the monopulse system, which is employed in the TTR, target position information is obtained each time a pulse is transmitted, reflected, and received. The monopulse system employs two pairs of radiating feedhorns that compare the amplitudes of a single returned pulse as it appears in the four feedhorns. By subtracting the signal strength received by one pair of horns from the signal strength received by the adjacent pair, a difference-signal is obtained. The azimuth and elevation difference-signals are utilized by other systems of the radar to keep the antenna pointed at the target.

d. **Receiving system.** The receiving system (fig 2) converts the X-band signals (sum, azimuth difference, and elevation difference RF signals) applied from the RF (monopulse duplexer) and antenna system, into 60-megahertz IF signals. By using these three IF signals, the receiving system generates direct current azimuth and elevation error signals that are subsequently applied

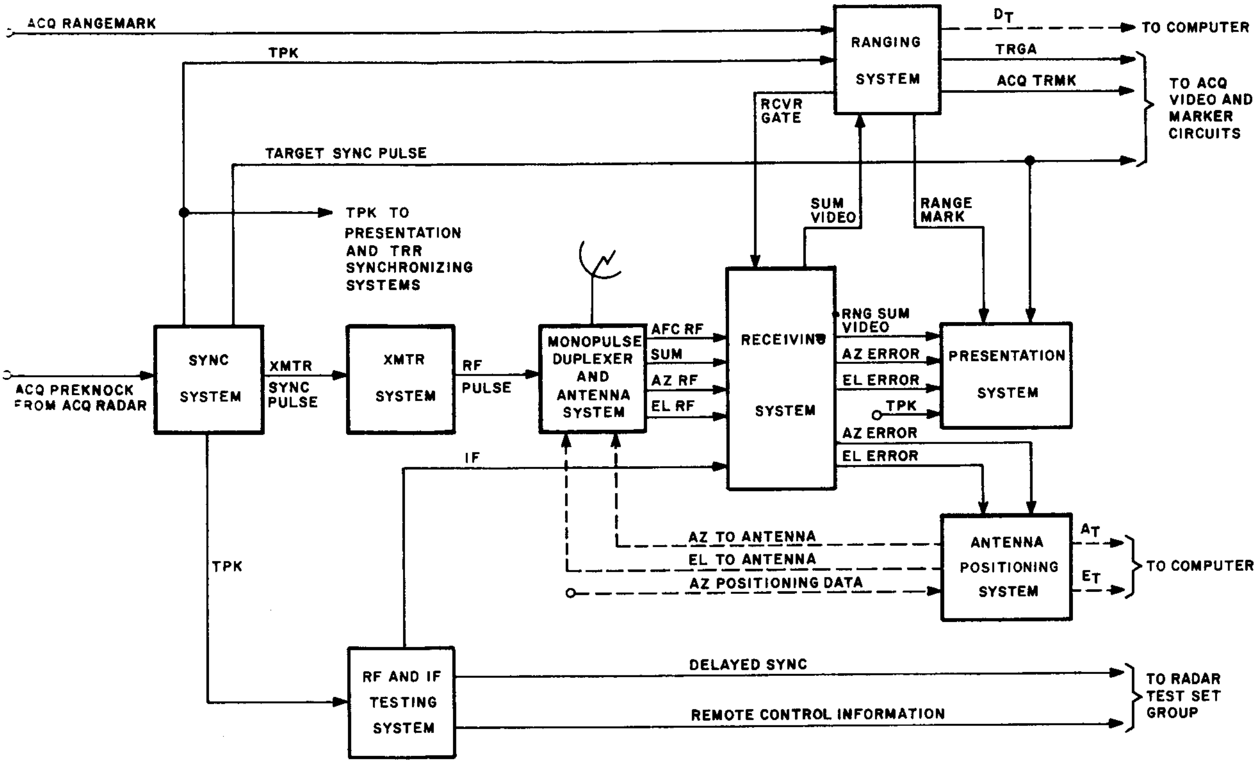

Figure 2. Functional block diagram of target track radar.

to the antenna positioning system. The sum IF signal is detected and applied to the track ranging system as the target range video signal. In addition, sum, azimuth errors, and elevation error video signals are applied to the presentation system for the CRT displays. Only those pulses received from the target being tracked are gated by the track receiver gate which is applied to the receiving system. This gating is necessary in order to reduce or eliminate echoes received from undesired targets in the vicinity.

e. **Ranging system.**

(1) The ranging system (fig 2) determines the time between the transmitted pulse and the received target echo. Since the range of the target is proportional to the time interval between the transmitted pulse and the target echo, measuring the time interval determines the range. Three means are provided for controlling the measuring circuits after the target is acquired: manual, aided, and automatic. Manual and aided ranging can be used for acquiring a target. All three ranging methods can be used after the target is acquired by TTR to provide range data for the computer. The circuits of the ranging system are triggered by the preknock pulse during normal operation. During calibration, a calibration sync pulse is applied to the target ranging system to replace the preknock pulse. During normal operation, the preknock pulse initiates operation of the ranging system. After a controllable time delay, the ranging system produces the receiver gate (RCVR gate) which is sent to the receiver system and can be centered around the sum target video to give an indication of target slant range (D_T).

(2) During the designation and acquiring of a target, the acquisition radar range and azimuth data are transferred to TTR. The TTR uses this data (acq rangemark and az position data) to slew the TTR range and antenna system to the range and azimuth of the designated target. When the elevation operator manually "acquires" the target is in the TTR beam and all three target coordinates (A_T, E_T, and D_T) now appear on the TTR indicators. These coordinates (A_T, E_T, and D_T) can now be sent to the computer. Also, when the track antenna and range system slews to the designated target position, the track range gate (TRGA) and acq track rangemark (acq TRMK) are sent to the video and marker circuits in the battery control van. This causes the electronic cross to move to the coordinate of the designated target as described in lesson 2, paragraph 8b(5). The TRGA produces the radial line and the acq TRMK produces the arc of the electronic cross. Back in the radar control trailer, presentation of the target

coordinates enable the three track operators to manually track the target. Once the target is manually tracked in A_T, E_T, and D_T, automatic tracking may begin.

f. **Antenna positioning system.** The function of this system is to correct the antenna position so that it points directly at the target at all times. Manual and aided positioning are employed for acquiring the target. Automatic positioning keeps the antenna on-target at all times without the aid of the operators. The antenna is positioned by direct current azimuth and elevation error signals (fig 2) provided by the receiving system.

g. **Presentation system.** The target track radar presentation system consists of three A scan indicators which provide visual tracking information in three coordinates: azimuth, elevation, and range. These indicators are used in manual and manual-aided tracking of a target and supply helpful information during automatic tracking. Thus, the presentation system is the visual link between the target and the TTR operators. Three 5-inch A type scopes and a B scope appear on the target tracking control console in the trailer mounted tracking station. The B scope, which provides a visual link between the acquisition and track system, was discussed in the LOPAR lesson.

h. IF and RF testing systems.

(1) IF test system. The IF test system (fig 2) produces a 60-megahertz IF test signal for testing the TTR system. The target preknock pulse from the synchronizing system triggers the IF test system. A 60-megahertz IF test signal, capable of variable delay, is applied to the main IF amplifiers in the receiver system when tests, calibrations, and adjustments are being performed.

(2) RF test system. The RF test system (fig 2) remotely controls the operation of the radar test set group during testing of the overall RF performance of the TTR system. The target preknock pulse is applied to the RF test system to develop a delayed sync pulse which triggers the radar test set group into operation. The radar test set group generates test signals used to check the receiver system. Controls in the RF test system vary the frequency, amplitude, and apparent range of these test signals by applying remote control information to the radar test set group.

4. FUNCTION OF SYNCHRONIZING SYSTEM.

a. **General.** The synchronizing system generates pulses that trigger the transmitter system and synchronize the various range determination circuits of the range and presentation system in the TTR. The synchronizing system also supplies a target preknock pulse to the TRR system. The TTR transmitter system is synchronized with the acquisition radar transmitter system to insure simultaneous triggering of both transmitters; thus, identical range zero references for both radars. The synchronizer is triggered by the 1-microsecond acquisition preknock pulse. Identical acquisition track synchronizers are used in the director station (LOPAR) and in the TTR system. The synchronizing system provides five outputs: a target preknock pulse, a target sync pulse, a transmitter sync pulse, a test pulse, and an IFF trigger pulse. The test pulse and the IFF trigger pulse are used only in the acquisition radar system.

b. **Target preknock pulse.** The target preknock pulse from the synchronizing system is a 1-microsecond pulse at the PRF of the selected acquisition radar. This preknock pulse (fig 2) triggers the presentation system, the range system, and the target test IF signal generator in the RF and IF testing system. The target preknock pulse is applied to these units prior to application of the transmitter sync pulse and the target sync pulse to the other units. This allows the range system and presentation system to stabilize before the transmitter is triggered. The target preknock pulse also synchronizes the radar test set with the TTR system and is applied to the video time share amplifier in the TRR synchronizing system to develop a modified preknock pulse for the TRR.

c. **Target sync pulse.** The target sync pulse from the synchronizing system is a 0.15-microsecond pulse that is applied to the B scope indicator and mark generator of the presentation system. This pulse is delayed after the target preknock pulse by 22.5 microseconds during long pulse operation and 24.5 microseconds during short pulse operation.

d. **Transmitter sync pulse.** The transmitter sync pulse from the synchronizing system is a 0.1-microsecond pulse which occurs in coincidence with the target sync pulse. It is used to trigger the transmitter system.

5. FUNCTION OF TRANSMITTER SYSTEM.

a. **General.** The TTR transmitter system (fig 3) converts low-voltage pulses from the synchronizing system into long or short bursts of RF energy. These bursts are applied to the target track antenna-receiver-transmitter group. The repetition rate of the transmitter is controlled by the synchronizing system.

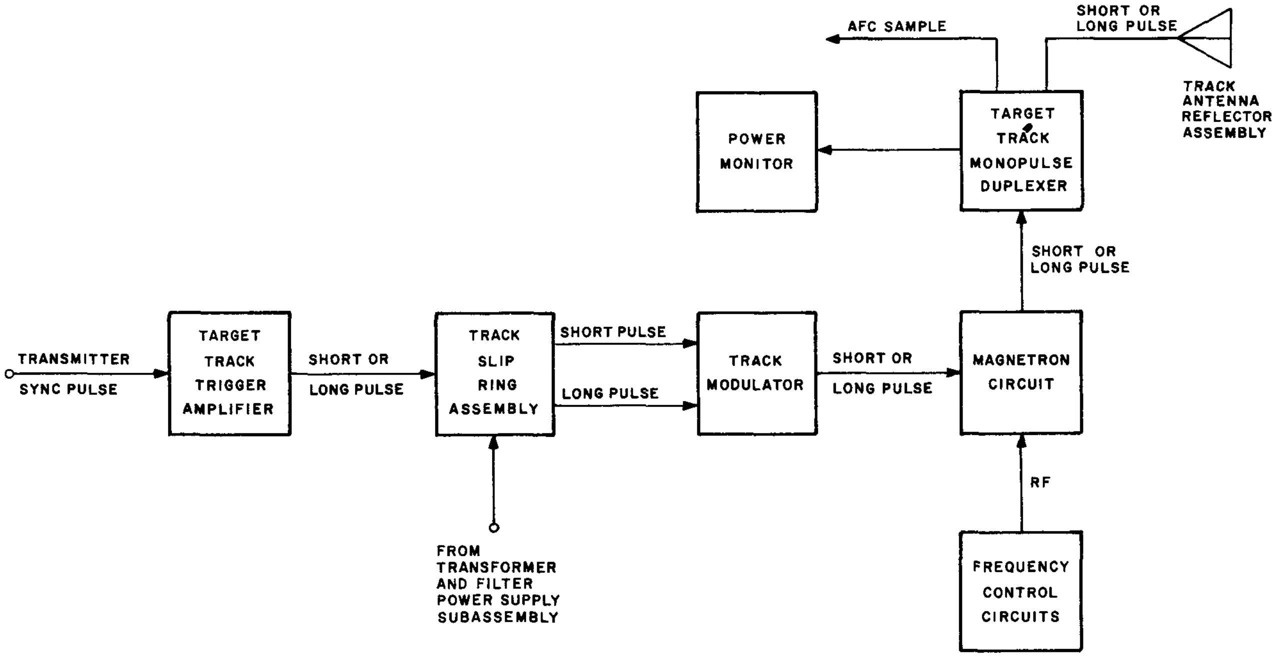

Figure 3. TTR transmitter system - block diagram.

b. **Block diagram analysis.** The positive transmitter sync pulse from the synchronizing system is applied to the target track trigger amplifier (fig 3). The amplified positive pulse is applied through the track slip ring assembly to the track modulator for use as a trigger pulse. A negative DC voltage from the transformer and filter power supply subassembly is applied through the track slip ring assembly to furnish high voltages for the modulator. Further amplification and shaping by the modulator circuits produces a pulse that triggers the magnetron. The frequency of the magnetron output (X-band) is selected by the frequency control circuits. The RF pulses from the magnetron are applied through the target track monopulse duplexer to the track antenna reflector assembly for radiation into space. A sample of RF energy for the target track monopulse duplexer is coupled to the power monitor, giving an indication of transmitter power and transmitter power loss. An AFC sample of RF energy is also coupled to the skin track AFC circuits to control the frequency of the local oscillator in the receiver.

c. **Target trigger amplifier.** The target track trigger amplifier (fig 3) produces high voltage trigger pulses for the track modulator.

d. **Track modulator.** The track modulator (fig 3) receives the modulator trigger pulses at a high PRF for LOPAR operation, or a low PRF for HIPAR operation, and produces a negative short or long pulse to trigger the magnetron into oscillation.

e. **Magnetron circuit.** The magnetron circuit (fig 3) produces short or long high power RF energy pulses. These pulses are applied through the target track monopulse duplexer to the track antenna reflector assembly and radiated into space.

f. **Parabolic antenna.**

(1) General. The parabolic reflector, which is composed of a main reflector and a subreflector, radiates the transmitted RF energy into space in a very narrow beam and also concentrates the received signal energy at its focal point.

(2) Operation. The output of the waveguide and feedhorns is horizontally polarized RF energy. When this energy strikes the subreflector, it is reflected back to the main reflector where its polarization is changed to vertical before being radiated through the subreflector into space. The subreflector is transparent to vertically polarized energy and reflects only horizontally polarized energy. Vertically polarized energy, reflected from a target, passes through the subreflector to the main reflector where it is shifted to horizontally polarized energy. This energy is reflected back to the subreflector where it is again reflected through a fiberglas cone to the feedhorns. This energy presented to the feedhorns is the reflected signal from a target. Horizontally polarized energy, which bypasses the subreflector, strikes the main reflector where it is changed to vertically polarized energy and reflected back

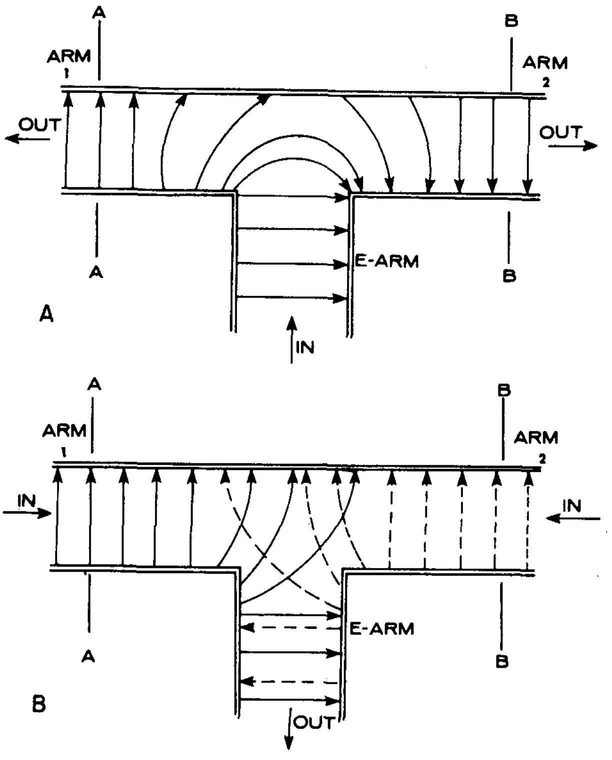

Figure 4. Tee junctions.

through the subreflector as unwanted energy.

g. **Target track monopulse duplexer.** The target track monopulse duplexer (fig 3) contains the waveguide and feedhorns that convey the magnetron RF energy to the track antenna reflector assembly. The monopulse system, which uses one waveguide assembly as a common channel for transmitting and receiving, requires a switching arrangement whereby the receiving system presents an infinite impedance to the transmitted pulse; and the transmitting system presents an infinite impedance to the received pulse. This switching action is accomplished by four ATR tubes and three TR tubes. The TR tubes protect the crystal detectors of the receiving system from the high power transmitted pulses. The ATR tubes apply the weak echo signals to the receiving system.

h. **The hybrid tee junction.** A hybrid tee junction can be described as a dual electromagnetic plane type of tee junction. The monopulse system employs four such junctions to join the monopulse duplexer. They are discussed below.

(1) A cross-sectional view of an electric plane junction is shown in A of figure 4. It shows lines of electric intensity, drawn in successive positions, of the same wavefront entering arm E. It also indicates what happens when the waves reach the junction point and the phase relationship between the outputs, arms 1 and 2. Although there is some reflection at the junction point (not shown), the input energy tends to divide equally between arms 1 and 2. If planes AA and BB are equidistant from the center of the junction, the output of arms 1 and 2 will be equal magnitude but of opposite polarity.

(2) Wavefronts entering arms 1 and 2 of the tee are illustrated in B of figure 4. If the two entering wavefronts are of equal magnitude and of the

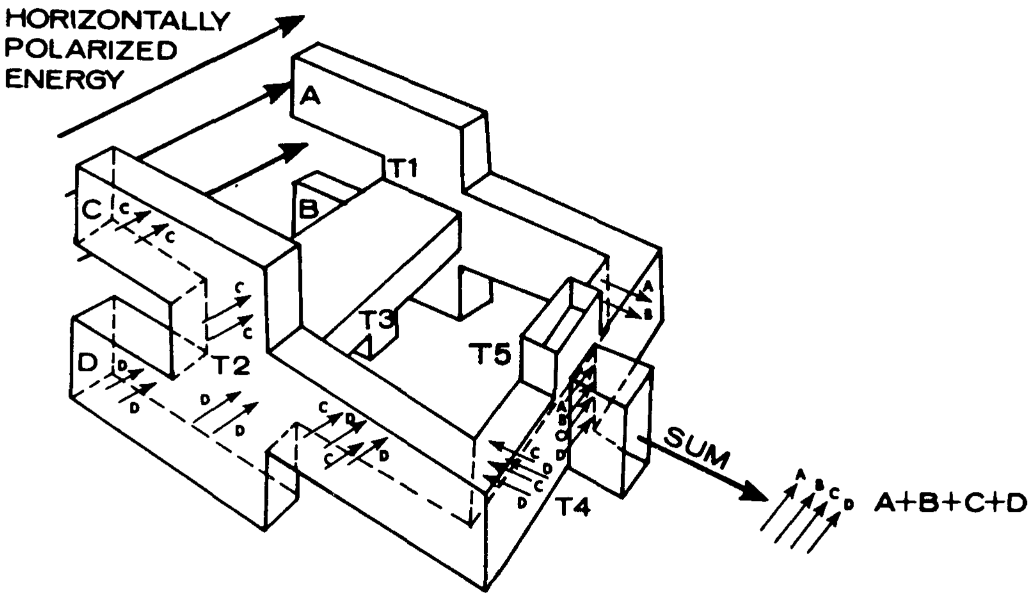

Figure 5. Sum signal from monopulse duplexer.

same polarity at planes AA and BB, upon reaching the E arm they will completely cancel each other and no output will result. If the two entering wavefronts are of different magnitudes but of the same polarity, their magnitude difference will appear in the E arm.

6. RF RECEPTION.

a. **Sum signal.** Range is determined by the sum signal (fig 5) which is the sum of all energy received by the four feedhorns. Assume that the monopulse duplexer receives horizontally polarized energy through the four feedhorns A, B, C, and D. The energy is shown by arrows. At T2, the energy from C and D adds, since the C energy arrows and the D energy arrows are in the same direction (same polarity). The energy from A and B horns is added in the same manner at T1. At T4, the energy from T1 and T2 is added by the same method as described in paragraph 5h(2). The sum signal is therefore the total energy received by all four feedhorns or A + B + C + D.

b. **Azimuth difference signal.** Figure 6 shows how the azimuth difference signal is obtained. The energy from feedhorns A and B (arrows A + B) enters T5 from the right, and energy from feedhorns C and D (arrows C + D) enters T5 from the left. The energy from A and B is 180 degrees out of phase with energy from C and D. Therefore, the resulting energy output (azimuth difference) is (A + B) - (C + D) or the difference in

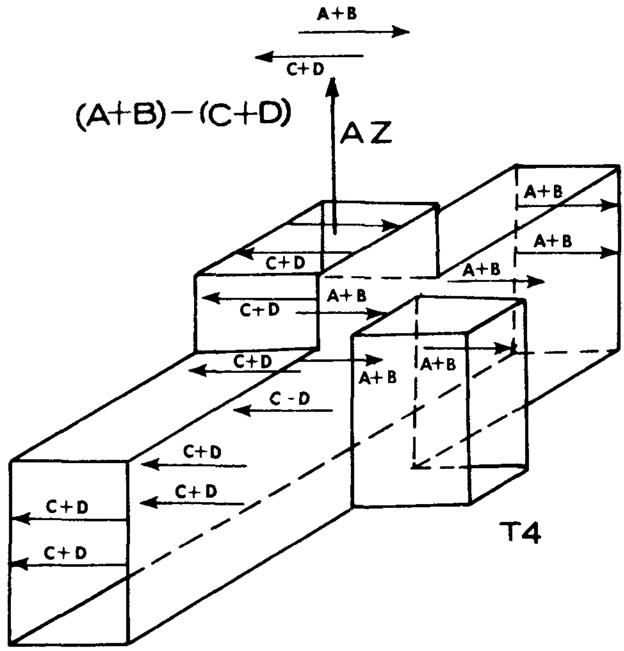

Figure 6. Azimuth difference from monopulse duplexer.

energy level between the right two feedhorns and the left two feedhorns.

c. **Elevation difference signal.** The elevation difference is obtained from T3 as shown in figure 7. The portion of the plane at the right is one wall of T1. The energy from A enters T3 from the top while the energy

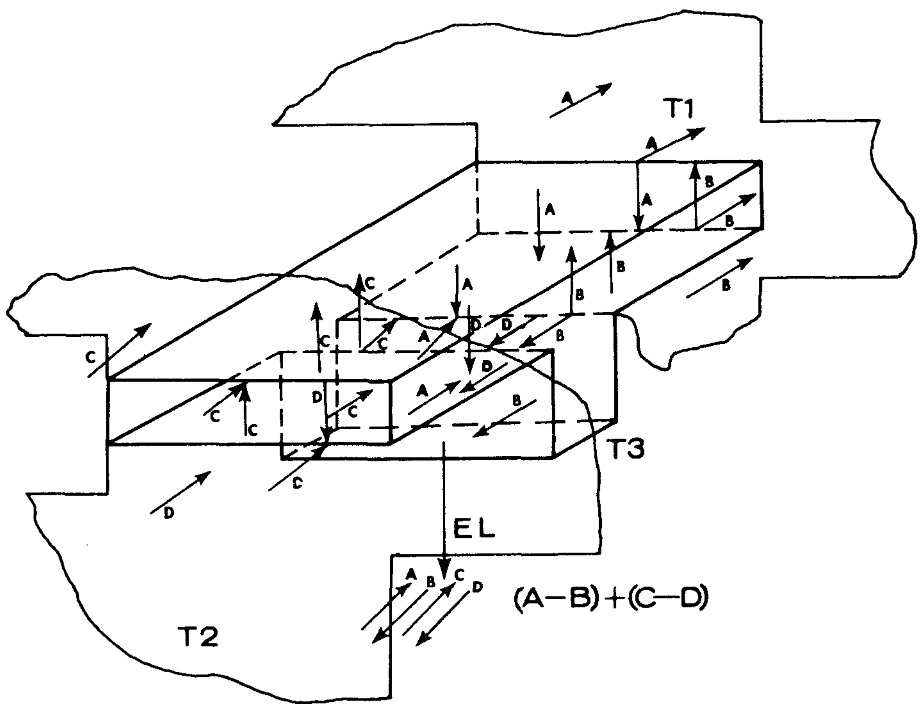

Figure 7. Elevation difference from monopulse duplexer.

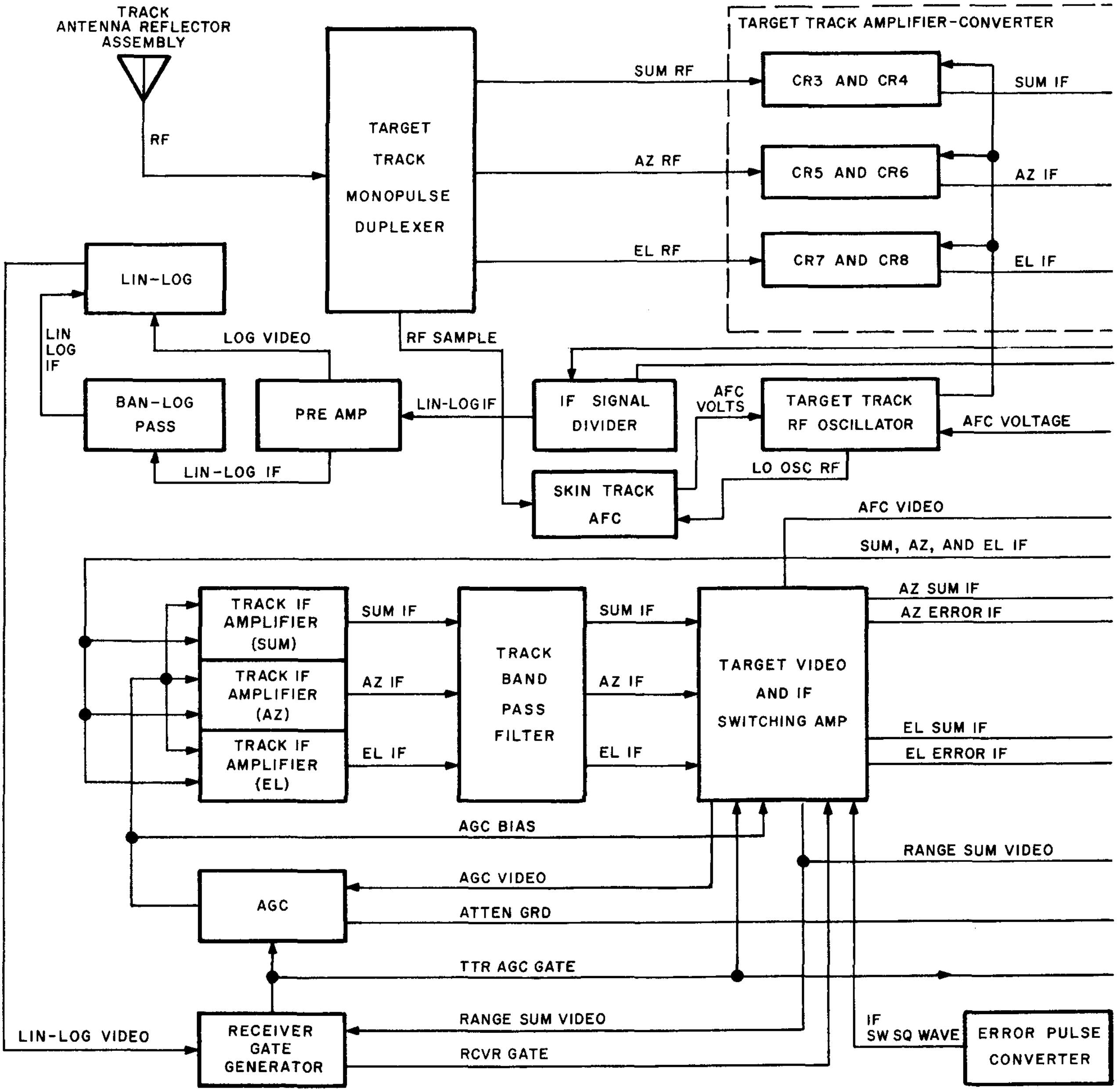

Figure 8. TTR receiver system.

from B enters from the bottom. Upon entering T3, energy B becomes 180 degrees out of phase with energy A. Therefore, the energy entering T3 from the right is the difference between energy A and energy B or (A - B). Similarly, the portion of the plane shown at the left is one wall of T2. The energy from C enters T3 from the top and the energy from D enters T3 from the bottom. As energy C and energy D enter T3, energy D becomes 180 degrees out of phase with energy C. Therefore, the energy entering T3 from the left is the difference between energy C and energy D or (C - D). As energy difference (A - B) enters the center leg, T3, it is added to energy difference (C - D). The resulting output is therefore (A - B) + (C - D) or the difference in energy between the top two feedhorns and the bottom two feedhorns. The difference signals, azimuth and elevation, are processed to move the antenna so that it is always pointing at the target.

7. FUNCTION OF RECEIVER SYSTEM.

a. The TTR receiver system (fig 8) converts the sum, azimuth, and elevation RF signals from the target track monopulse duplexer into 60-megahertz IF signals.

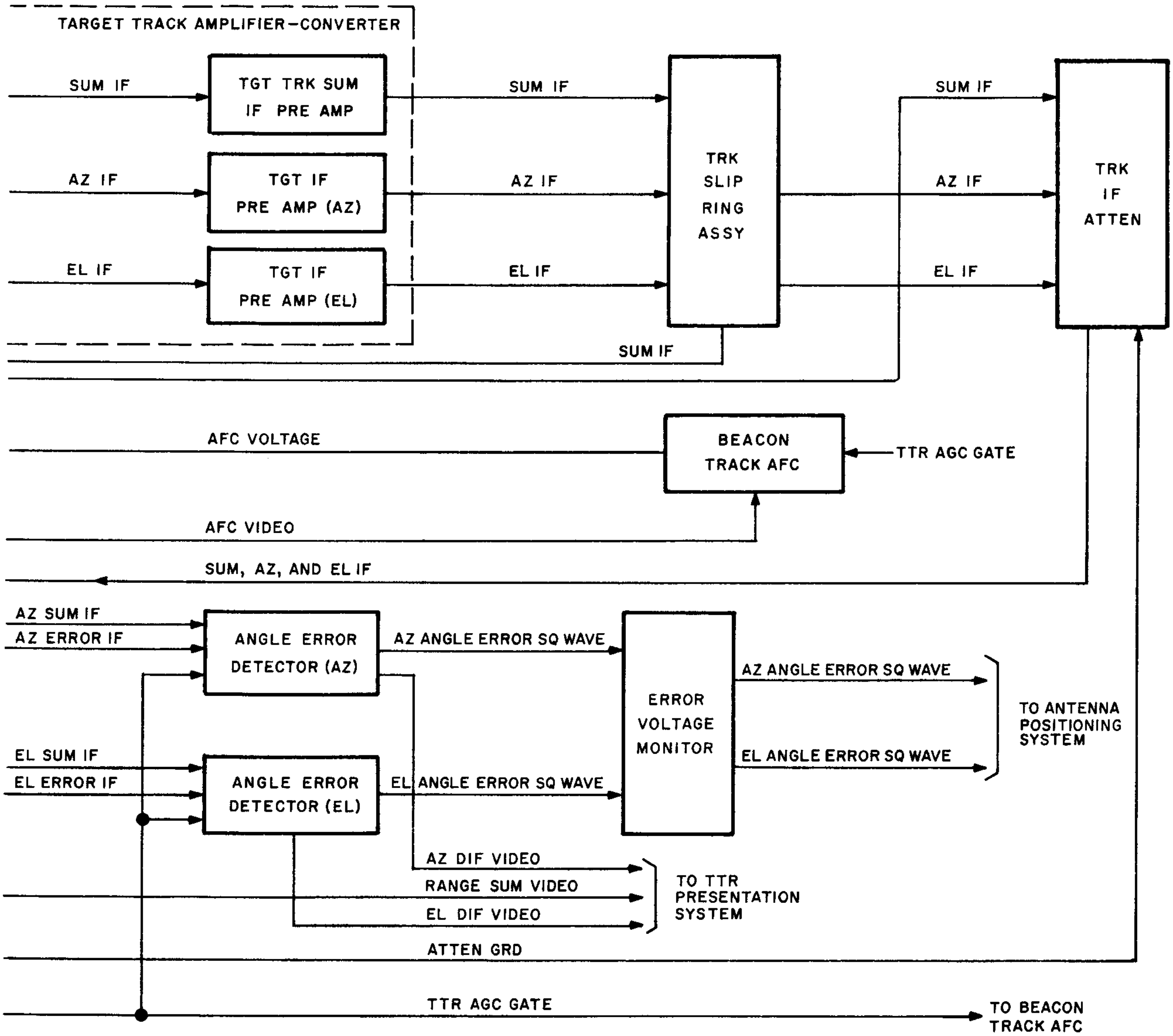

Figure 8. (Continued)

The receiver system uses one of two modes to amplify the IF signals to a usable level and converts them to video. The receiver system contains a conventional AGC controlled receiver circuit and a linear-logarithmic (lin-log) receiver designed to provide full gain to all input signals within its dynamic range. The lin-log receiver provides target video that would normally be below the visible level if conventional AGC action were used. Azimuth and elevation angle error square waves, developed by the receiver system, are applied to the azimuth and elevation antenna positioning circuits, respectively, to correct the antenna pointing error. Range sum video, azimuth difference video, and elevation difference video from the receiver system are applied to the presentation system for display on the target tracking indicators and the B scope indicator to assist the operators during manual tracking. Range sum video is also applied to the receiver gate generator in the range system and is used during automatic tracking.

b. The functional components of the TTR receiver system and associated circuits are located in the target track antenna-receiver-transmitter group at the antenna and in the radar set group in the radar control

trailer. Components in the target track antenna-receiver-transmitter group include the antenna reflector assembly, the target track monopulse duplexer, the target track amplifier-converter, and the target track RF oscillator. The reflector assembly is used in the transmitter and receiver systems.

c. Reflected RF signals are received at the track antenna reflector assembly (fig 8). These signals are channeled through the target track monopulse duplexer, which develops the sum, azimuth, and elevation RF signals, as described in paragraph 6, and applies them to converter section of the target track amplifier-converter, which contains converter crystals CR3 through CR8. The sum, AZ, and EL RF's are converted to 60 KHz by CR3 through CR8. From the converter crystals the signals are applied to their respective IF preamplifiers. The preamplifiers raise the signal amplitude of the sum, azimuth, and elevation IF signals for transmission through the track slipring assembly, which is located in the antenna support base, to the track IF attenuator and the track IF amplifiers in the radar set group. The IF signal divider at the output of the track sliprings (fig 8) functions to separate and supply equal amplitude sum IF signals to the track IF attenuator in the AGC controlled receiver and to the lin-log receiver circuits. The two channels of the IF signal divider are identical except for a manual gain control in the AGC channel. The IF preamplifier in the lin-log receiver divides the lin-log IF into two channels. The low level IF signals are given linear amplification in the linear channel and the high level signals are given logarithmic amplification in the log channel. The high amplitude signals are detected into a log video signal if the final stage to the IF preamplifier draws grid current. The IF signals from the linear channel are also detected in the cathode of the succeeding lin-log amplifier at any time the linear IF signal causes an IF amplifier to draw grid current. This cathode detected log video is summed across a common cathode resistor. The bandpass filter, which is in the linear channel, is used to control the receiver bandwidth during long or short pulse operation as discussed in d below. At the output of the lin-log amplifier, both the lin and log video signals are added at their proper time (not in coincidence) and applied to the receiver gate generator. The lin-log action results in nearly equal amplitude video regardless of return signal strength.

d. The gain of the track IF amplifiers is controlled by an automatic gain control (AGC). The IF amplifiers increase the amplitude of the input signals and compensate for phase shifting in the signals by reestablishing the phase relationship that existed at the output of the target track monopulse duplexer. Sum, azimuth, and elevation IF signals from the track IF amplifiers are applied through the track bandpass filter to the target video and IF switching amplifier. The bandpass filter is switched into the IF signal paths to obtain the maximum range capability of long pulse operation. The bandpass filter reduces the bandwidth of the receiver system and reduces the overall noise. This increases the signal-to-noise ratio and yields an increased maximum range. During short-pulse operation, the sum, azimuth, and elevation IF signals are applied directly to the target video and IF switching amplifier, bypassing the track bandpass filter.

e. AGC bias voltage developed from AGC video by the AGC circuit is applied to control the gain of the sum, AZ and EL IF amplifiers, and the two IF amplifier stages in each channel of the target video and IF switching amplifier.

f. The outputs from the target video and IF switching amplifier are range sum video, AFC video, AGC video, azimuth and elevation sum IF, and azimuth and elevation error IF. Range sum video is applied to the receiver gate generator where it or TTR lin-log video may be selected and applied to the TTR presentation system (as discussed in paragraph 8c) for display on the tracking indicators. The AFC video is applied to the beacon track AFC, which develops AFC voltage to control the frequency of the local oscillator in the target track RF oscillator (local oscillator) while checks and adjustments are being performed. During normal operation, AFC voltage, from the skin track AFC controls the local oscillator frequency. The TTR AGC gate, from the receiver gate generator, is applied to the beacon track AFC to obtain an AFC sample at the range setting of the radar. Azimuth sum and error IF signals are applied to the azimuth angle error detector and elevation sum and error IF signals are applied to the elevation angle error detector.

g. The 0.4-microsecond TTR AGC gate pulse from the receiver gate generator is also applied to the azimuth and elevation angle error detectors to develop the azimuth and elevation angle error square-wave signals. The phase of the square-wave signal output is determined by the direction of pointing error, and the amplitude is proportional to the amount of error. The azimuth and elevation angle error square waves are applied through the error voltage monitor to the antenna positioning system to correct antenna pointing error. The angle error detectors also produce azimuth and elevation difference video signals (polarity representing direction of the error) that are applied to the TTR

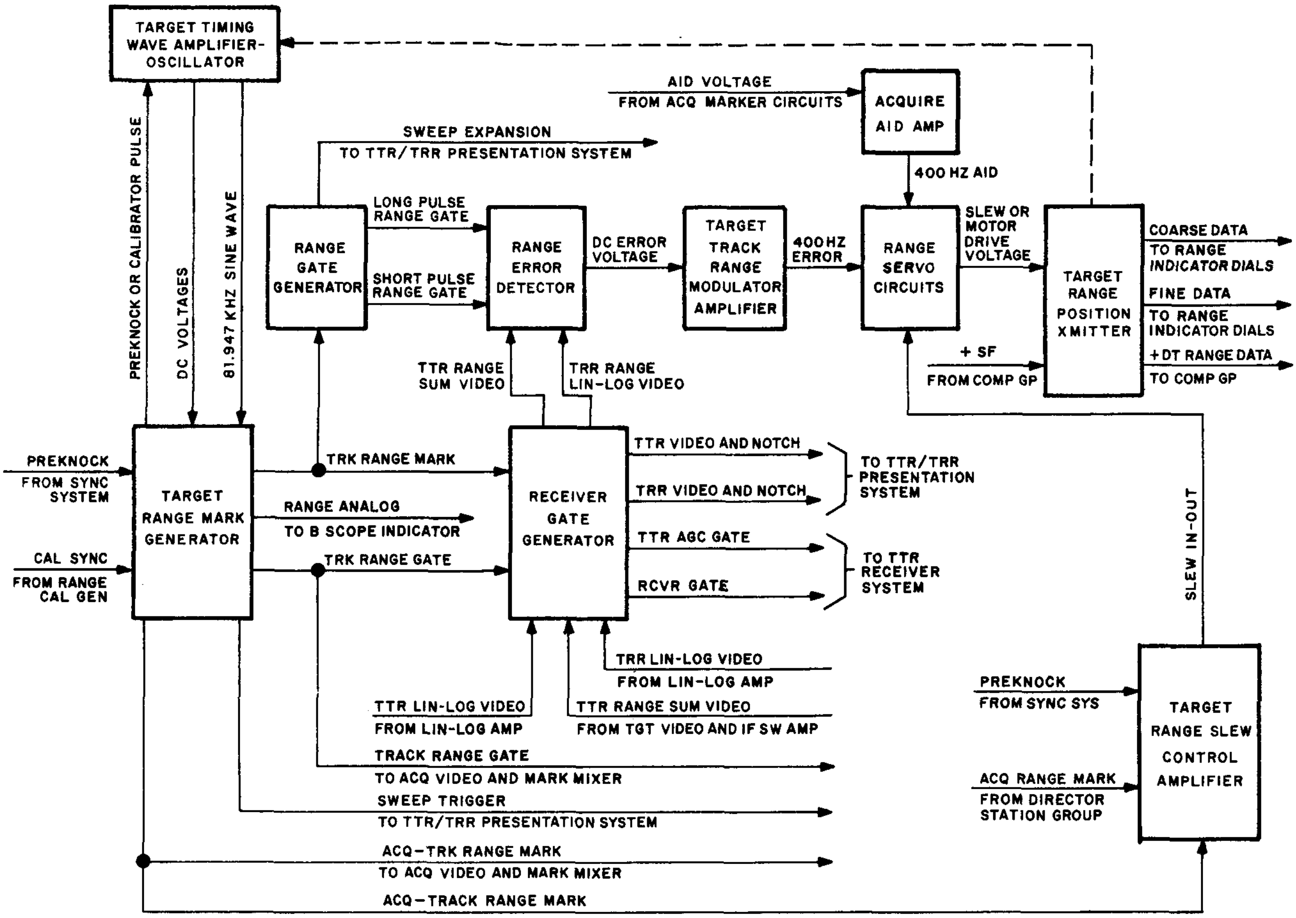

Figure 9. Ranging system.

presentation system for display on the azimuth and elevation indicators.

h. The skin track AFC system maintains the receiver IF at 60 megahertz above the transmitter frequency during normal operation. A beacon track AFC system is used during testing. A directional coupler in the target track monopulse duplexer extracts sample RF energy from the transmitted pulses and applies the sample RF to the skin track AFC system (fig 8). The mixer section in the skin track AFC mixes the sample RF with local oscillator RF to produce 60-megahertz AFC IF signals. If the AFC IF is more than ±3 MHz from 60 MHz the AFC system goes into a search mode until the AFC IF is within 63 to 57 MHz, then the skin track AFC goes into a tracking mode. During the tracking mode the frequency deviation from 60 MHz is converted (by a discriminator) into a positive or negative AFC voltage depending on the direction of the frequency deviation. This positive or negative AFC voltage controls the conduction of a tuner diode which tunes the local oscillator. The AFC will lock up when the local oscillator is oscillating 60 MHz above the transmitting frequency.

8. FUNCTION OF RANGING SYSTEM.

a. Range system components (fig 9) are located in the radar set group and the target radar control console inside the trailer mounted tracking station. The preknock pulse (fig 9) from the synchronizing system triggers the target rangemark generator. This signal is coupled through the target rangemark generator to the target timing wave amplifier-oscillator. The sine-wave timing signal (initiated at preknock) and two range analog DC voltages are applied to the target rangemark generator from the target timing wave amplifier-oscillator. During calibration, a calibration sync pulse is applied to the target rangemark generator from the range calibrator generator to replace the preknock pulse for calibrating the range system. One output of the target range mark generator is the track rangemark which triggers the range gate generator and receiver gate generator. Other outputs include an acquisition-track rangemark applied to the acquisition video and mark mixer and to the target range slew control amplifier; a

sweep trigger applied to the range, azimuth, and elevation indicators of the combined TTR and TRR presentation system; a track range gate applied to the receiver gate generator and to the acquisition video and mark mixer; and range analog voltage applied to the B scope indicator.

b. The range gate generator supplies long and short pulse range gates to the range error detector and a sweep expansion pulse to the TTR and TRR presentation system.

c. The receiver gate generator receives TTR range sum video from the target video and IF switching amplifier and TTR and TRR lin-log video from the receiver circuits. Both TTR range sum video and TRR lin-log video signals are applied to the range error detector. Also, both TTR and TRR video are combined with a notch signal (representing the setting of the range system) in the receiver gate generator and applied to the TRR and TTR presentation system. The receiver gate is applied to the target video and IF switching amplifier in the receiver and allows only the AZ and EL IF occurring during the receiver gate to pass to the output. In addition to gating the AFC, the TTR AGC gate also gates the generation of angle error square waves from the angle error detectors in the receiver (paragraph 7g).

d. The range error detector develops a DC error voltage by comparing the long or short gate with the sum video for automatic tracking operation. Polarity of this error signal indicates direction of range error, and the amplitude indicates amount of range error. The error signal is applied to the target track range modulator amplifier, which produces a 400-hertz error signal. In automatic range tracking, this signal is applied to the range servo circuits which drive the target range position transmitter.

e. During target acquisition, an acquisition aid voltage from the acquisition marker circuits drives the range servo circuits. This voltage is amplified by the acquire aid amplifier. Manual and aided control of the range servo circuits is also provided. In manual control, the range servo circuits are controlled by rotating the drive control handwheel. The speed and direction of servo operation are directly proportional to the speed and direction of handwheel rotation. Aided tracking can also originate with the handwheel. In this mode, the handwheel is manually displaced to control the tracking rate. The output of the range servo circuits is the "slew" or motor drive voltage applied to the target range position transmitter.

f. The target range slew control amplifier receives the acquisition-track rangemark from the target rangemark generator, the acquisition rangemark from the trailer mounted director station group, and the preknock pulse from the synchronizing system. Target range, designated by the acquisition radar, is represented by the acquisition rangemark, while the TTR range setting is represented by the acquisition track rangemark. The slew control amplifier compares the two time intervals between preknock and the marks described above and, when the time intervals differ, applies an output to a slew motor in the range servo circuits. This output causes the range servo circuits to slew in the proper direction to minimize the range error when TTR is acquiring a target from the acquisition radar.

g. The target range position transmitter is mechanically connected to the target timing wave amplifier-oscillator, the outputs of which vary with the range setting because of this mechanical connection. These outputs are an 81.947-kilohertz sine-wave, phase-shifted in proportion to range, and two DC voltages which change the time the track rangemark is generated. As the track rangemark moves in time, the long or short gates from the range gate generator are moved toward the TTR or TRR video. When the long or short gate alines with the TTR or TRR video, errors are no longer produced and the target is being tracked. Accurate target slant range (D_T) is now the output of the target range position transmitter. In addition, the TTR or TRR video is now centered in the notch for display on the presentation system (fig 13). The target range position transmitter receives a +SF (scale factor) voltage from the computer.

9. FUNCTION OF ANTENNA POSITIONING SYSTEM.

a. General. The antenna positioning system steers the TTR antenna in azimuth and elevation in order to keep the antenna pointing at the target. When this condition exists, the system provides the computer with target azimuth and elevation position data. The antenna may be steered either manually or automatically. When manually steered, a handwheel (fig 10) is turned for each coordinate. The handwheel circuits supply control voltages for the corresponding coordinate servo circuits. In the automatic mode (fig 11), the control voltages are supplied by the angle error detectors discussed in paragraph 7g.

b. Additional functions. Additional functions of the system are:

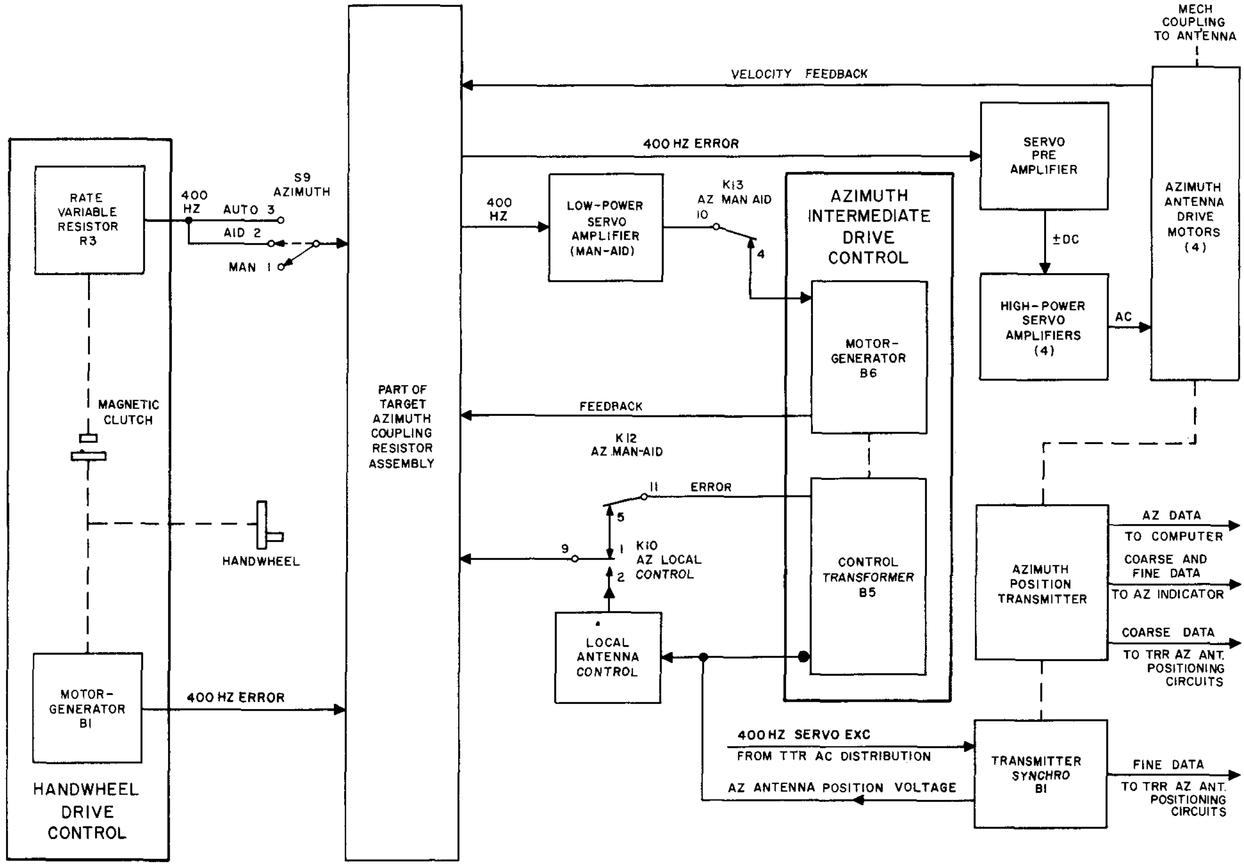

Figure 10. TTR azimuth antenna positioning circuits (manual-aided).

(1) To provide for rapid slewing of the range unit and antenna in azimuth (when acquiring a target).

(2) To supply target azimuth and elevation data to the computer.

(3) To provide remote indications of the present target azimuth and elevation.

(4) To position the TRR antenna in azimuth and elevation.

c. **Antenna positioning system components.** Eight antenna drive motors position the antenna in two coordinates: azimuth and elevation. Eight high power servoamplifiers supply power to the drive motors. The servo amplifiers are driven by an elevation preamplifier and an azimuth preamplifier. The azimuth and elevation servosystems each contain several small servomotors (similar to the ranging system), which drive small loads. Each servosystem contains two low power servoamplifiers which supply power to the small servomotors. The target azimuth coupling resistor assembly is used for impedance matching. The azimuth intermediate drive control and the elevation intermediate drive control provide a link between the low power and high power servo circuits. Two angle modulator amplifiers convert DC error signals (position errors) from the error pulse converter into 400-hertz control signals for automatic operation.

d. **Low power servoamplifiers.** The four low power servoamplifiers in the antenna positioning system are identical to those in the range servo circuits.

e. **Servo preamplifiers.** One servo preamplifier is used in the azimuth antenna positioning circuits and one in the elevation antenna positioning circuits. These preamplifiers amplify low level 400-hertz control voltages, demodulate them, and apply high level push-pull direct-current voltage to the high power servoamplifiers.

f. **High power servoamplifiers.** Four high power servoamplifiers are used in the azimuth antenna

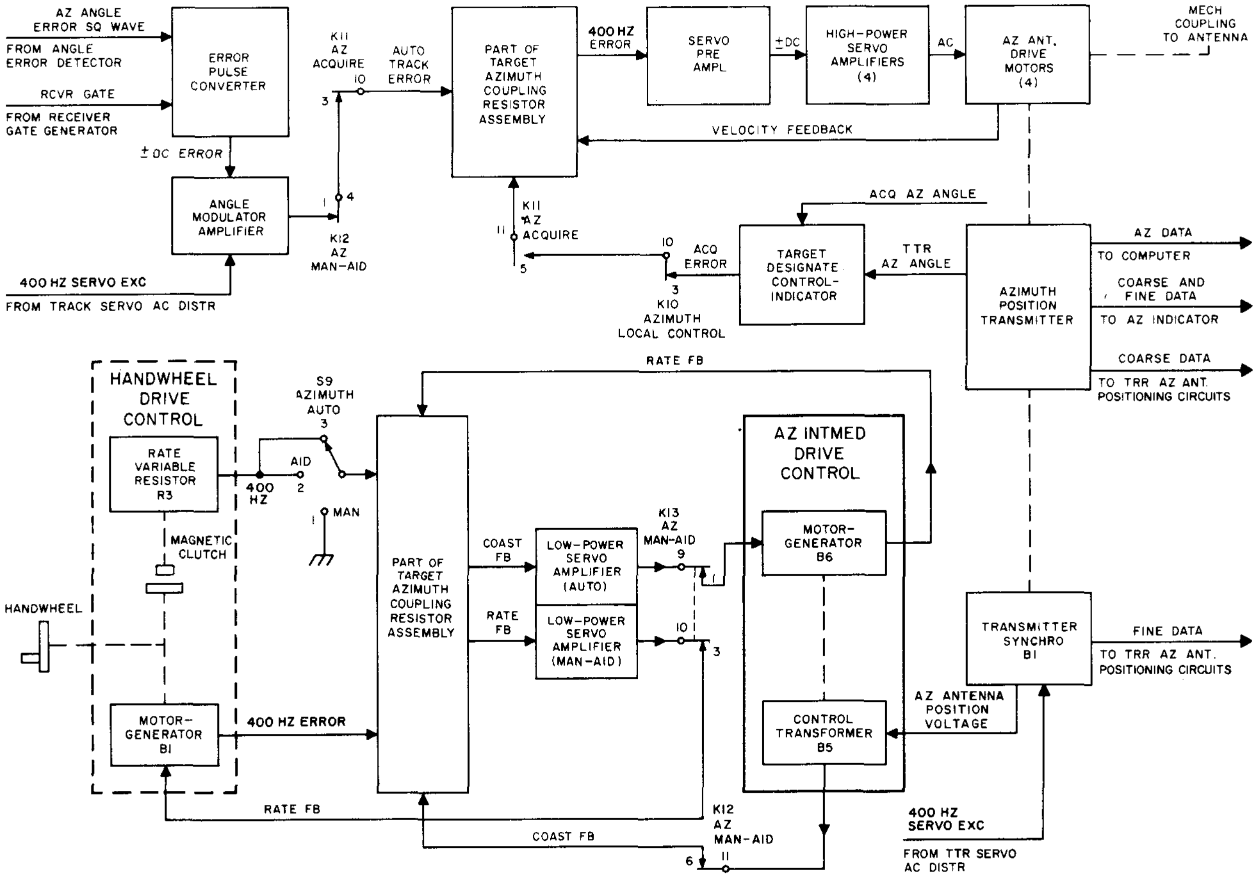

Figure 11. TTR azimuth antenna positioning circuits (auto-mode).

positioning circuits and four are used in the elevation antenna positioning circuits to supply power to the antenna drive motors.

g. **Error pulse converter.** During the automatic tracking mode the error pulse converter receives the azimuth angle error square wave and the elevation angle square wave from the angle error detectors and converts the information in the square waves to direct-current error signals.

h. **Angle modulator amplifiers.** Two identical and directly interchangeable angle modulator amplifiers are used in the antenna positioning circuits: one for elevation and one for azimuth. They are used only during automatic tracking operation or during testing. They receive the plus or minus direct-current error signals from the error pulse converter and modulate them with a 400-hertz servo X voltage. The resulting auto track error signal drives the antenna during automatic tracking.

i. **Intermediate drive controls.** The intermediate drive controls supply a 400-hertz voltage to the servosystem during manual or aided tracking. They also introduce a feedback signal, from the handwheel drive control, into the high power servo loop to stabilize the antenna.

j. **Position transmitters.**

(1) Azimuth position transmitter. The azimuth position transmitter is driven through the pedestal gearing by the azimuth antenna drive motors. It provides track antenna azimuth position error data to the target designate control circuits, drives coarse and fine azimuth data receivers and azimuth dials in the azimuth indicator, provides azimuth position data for the computer, and provides track antenna azimuth information for the acquisition radar presentation system.

(2) Elevation position transmitter. The elevation position transmitter provides elevation position data for the computer and drives coarse and fine elevation data receivers in the elevation indicator.

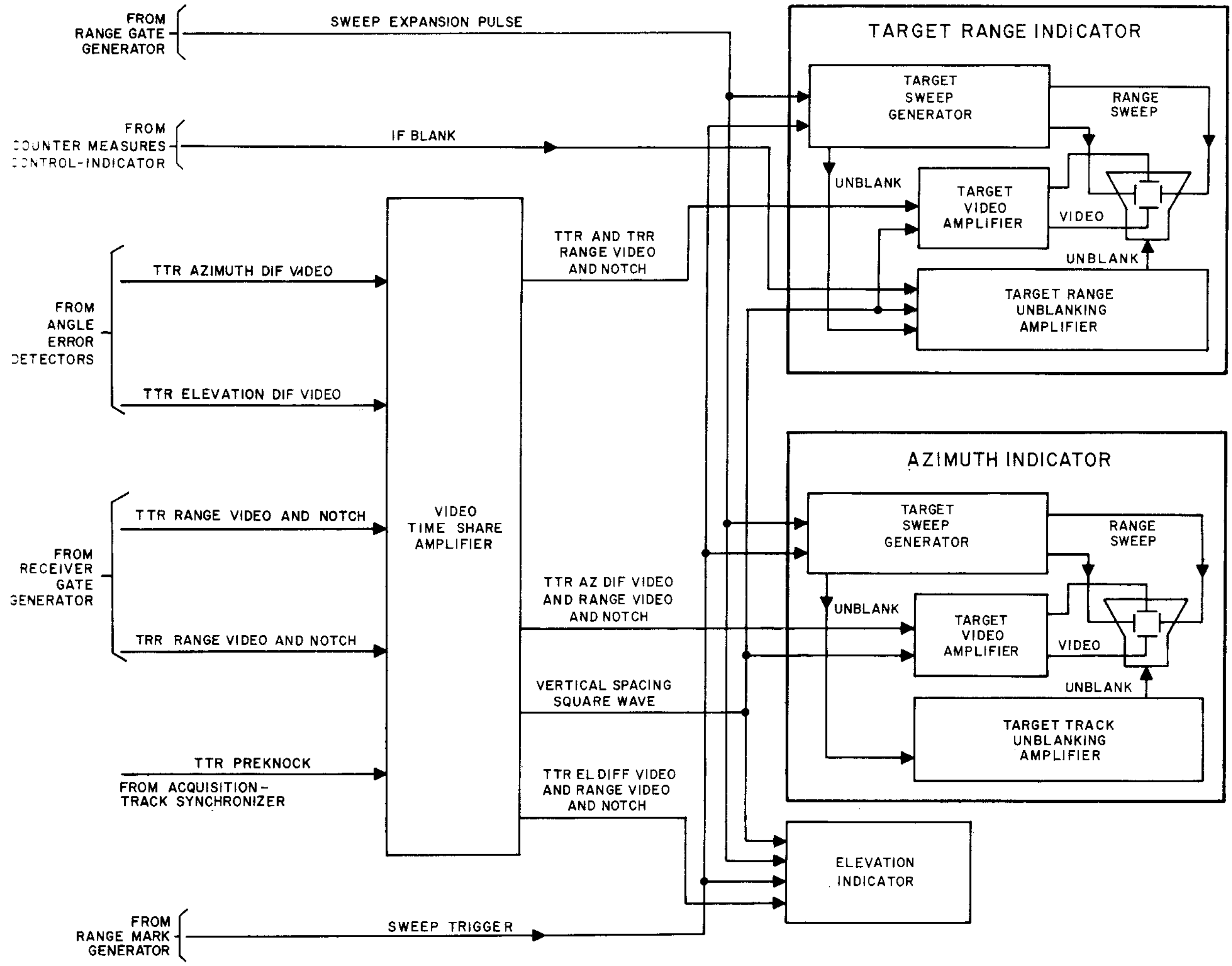

Figure 12. Presentation system.

10. GENERAL PRESENTATION SYSTEM.

a. **Target tracking radar (TTR).** The TTR presentation system (fig 12) provides visual indications of TTR range information and TTR azimuth and elevation pointing error. It also displays range information from the TRR system. The azimuth, elevation, and target range indicators present this information using signal inputs supplied by the video time share amplifier, which allows a dual trace presentation on each indicator. TTR range video and notch appears on the upper trace of the cathode ray tube (fig 13) of each indicator. TTR azimuth and elevation difference video is displayed on the lower trace of the azimuth and elevation indicators, respectively, while TRR video and notch is displayed on the lower trace of the range indicator (fig 13). Coarse and fine coordinate dials on the front panel of each indicator indicate radar range, TTR antenna azimuth, and TTR antenna elevation angle. A or R type sweeps are available for each indicator. The A sweep gives full range presentation; R sweep gives only a selected range portion. For convenience, provisions are made that allow the target range indicator to be used as a test oscilloscope.

b. **Video time share amplifier.** This amplifier (fig 12) generates the vertical-spacing square wave which provides time-share operation of the indicators and individual video outputs for each of the three indicators. The video time share amplifier receives TTR azimuth and elevation difference video signals from the respective angle error detectors (fig 8), TTR and TRR range video and notch signals from the receiver gate generator (fig 9) the TTR preknock pulses from the acquisition-track synchronizer (fig 2). The video time share amplifier contains four functional channels discussed in (1) through (4) below. A fifth channel, the modified TTR preknock pulse channel, is not used in the presentation system and will be discussed in lesson 5.

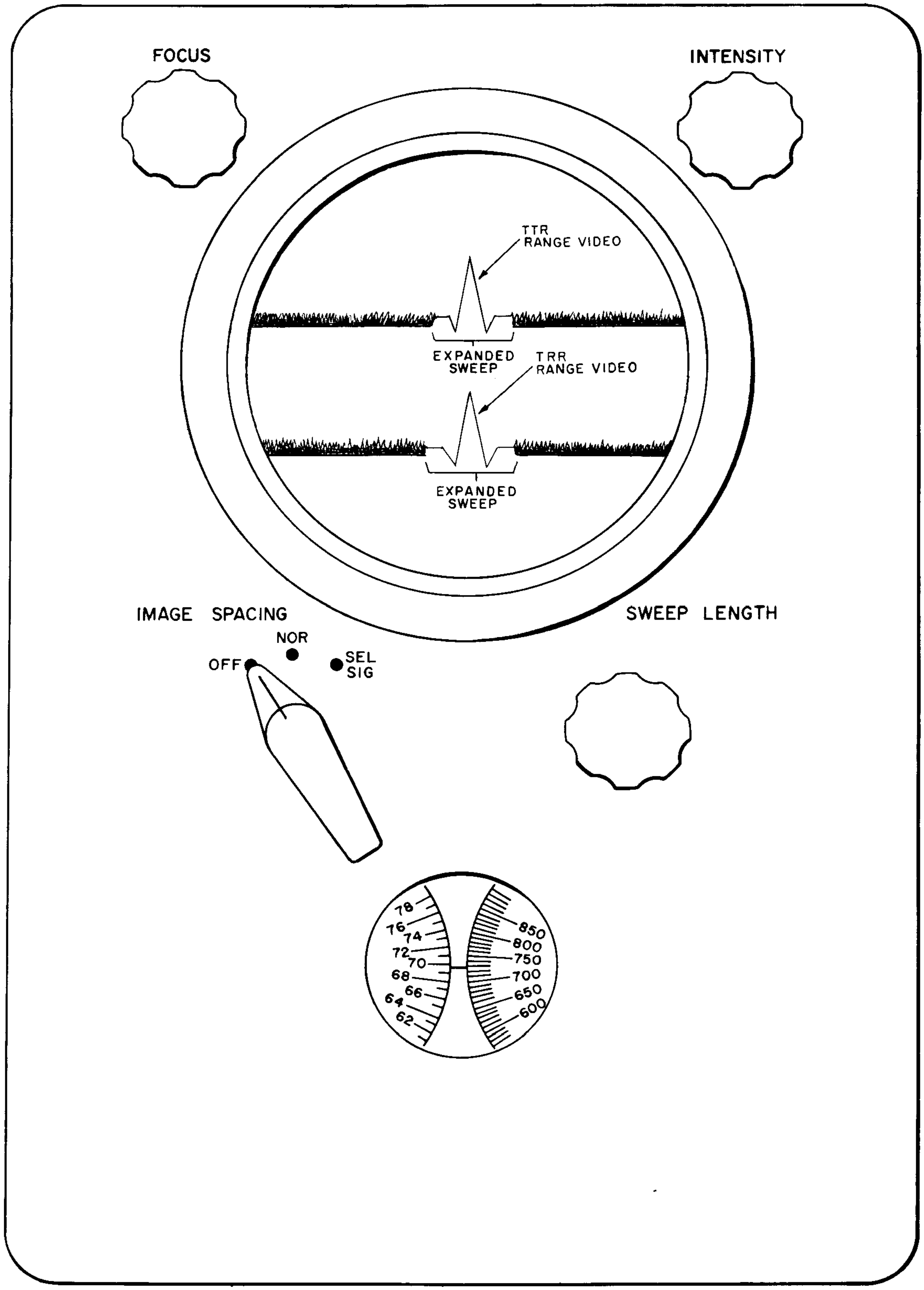

Figure 13. A scope - range indicator.

(1) Range video channel. The TTR and TRR range video and notch signals are gated on alternate cycles of the TTR preknock pulse and combined. The resulting output is one signal containing the TTR range video and notch during one preknock cycle and TRR range video and notch during the next preknock cycle. These signals are applied alternately to the target range indicator (fig 13). Relay circuits in the video time share amplifier permit the target range indicator to be used as a test oscilloscope. The other indicators are not used for this purpose.

(2) Azimuth video channel. The TTR range video and notch signal and azimuth difference video signal, which indicates a difference in antenna and target azimuth, are gated on alternate cycles and combined. The resulting azimuth video is applied to the azimuth indicator.

(3) Elevation video channel. The TTR range video and notch signal and elevation difference video signal, which indicates a difference in antenna and target elevation, are gated on alternate cycles and combined. The resulting elevation video output is applied to the elevation indicator.

(4) Vertical-spacing square wave channel. The vertical-spacing square wave channel receives the TTR preknock pulse and develops the vertical-spacing square wave which is applied to the elevation, azimuth, and target range indicators. This signal is positive during one preknock cycle and negative during the next, deflecting the horizontal trace up during one cycle and down during the next cycle. Gating voltages for the various signals in the video time share amplifier are also developed by the vertical-spacing square wave channel.

c. **Target range, azimuth, and elevation indicators.** The lower traces of the target range, azimuth, and elevation indicators are similar. The IF blank signal from the countermeasures control-indicator and the vertical-spacing square wave are applied to the target range indicator. These signals gate the unblank pulse from the target range unblanking amplifier, causing the cathode-ray tube (CRT) to remain blanked during retrace of the countermeasures control-indicator. This gating action occurs only in the lower trace of the target range indicator and prevents crosstalk interference from the countermeasures circuits from appearing on the CRT. Each indicator receives a video signal and the vertical-spacing square wave from the video time share amplifier (fig 12), a sweep expansion pulse from the range gate generator, and a sweep trigger from the rangemark generator (fig 9). The TTR range video and notch signal is displayed on the upper of the two traces on each indicator (fig 13). The TRR range video and notch is displayed on the lower trace of the target range indicator. The azimuth difference and elevation difference signals (antenna pointing errors) are displayed on the lower traces of the azimuth indicator and elevation indicator, respectively. Since the three indicators are similar, only the target range indicator is discussed in (1) through (3) below.

(1) Target video amplifier. The range video signal (fig 12), which consists of TTR and TRR range video and notch signals occurring on alternate cycles of the TTR preknock pulse, is applied to the target video amplifier. The vertical-spacing square wave (one-half cycle of which occurs for each cycle of the TTR preknock pulse) is also applied to the target video amplifier. The vertical-spacing square wave causes the video and notch signals to be used on a time-share basis. The signals are amplified and applied to the vertical plates of the CRT on alternate cycles of the system pulse repetition frequency and on alternate sweeps of the CRT. Without the square wave these signals would be superimposed on one trace, but since the square wave is negative during TTR video presentation and positive during the TRR presentation, the TTR range video and notch trace is displaced above the TRR range video and notch trace on the face of the CRT.

(2) Target sweep generator. The target sweep generator is triggered by the sweep trigger from the rangemark generator (fig 9). The sweep generator produces a push-pull saw-tooth range sweep voltage, which is applied to the horizontal deflection plates of the CRT. The sweep expansion pulse from the range gate generator increases the sweep rate, expanding a portion of the sweep corresponding to 500 yards. The expanded portion (fig 13) is centered around the range setting of the radar. The sweep generator also produces an unblanking pulse that is applied to the target range unblanking amplifier.

(3) Target range unblanking amplifier. The target range unblank amplifier amplifies the unblank pulse and applies it to the control grid of the CRT. This pulse allows the sweep to appear on the face of the CRT only during the trace and blanks the sweep during retrace. Two other inputs to the unblanking amplifier are the IF blank pulse from the countermeasures control-indicator and the vertical-spacing square wave from the video time share amplifier.

11. IF AND RF TESTING SYSTEM.

a. The IF test system (fig 2) provides a 60-megahertz target IF test signal for performing tests,

calibration, and adjustments of the TTR system. The IF test signal consists of short or long 60 MHz pulses that are variable in amplitude and apparent range. These pulses are used for testing the short and long pulse modes of operation. The IF test system aids in checking and adjusting the track IF amplifiers and the AGC. The IF test system is located in the trailer mounted tracking station and consists of a target test IF signal generator and associated test connections.

b. The RF system remotely controls the operation of the radar test set group (fig 18) when testing the overall RF performance of the TTR system. This system triggers the radar test set, which generates long and short pulse RF test signals. These RF signals are radiated from the tracking antenna horn and received by the TTR system, which uses them to check the receiver system. The RF test signals are varied in frequency, amplitude, and apparent range by controls in the RF test system. The RF test system for the TTR system is comprised of the target test control, the test delay control, and the test delay simulator.

(1) Test delay control. The test delay control in the missile radar control console is effectively a motor-driven variable resistor that supplies a variable DC voltage to the test delay simulator.

(2) Test delay simulator. The test delay simulator in the missile radar control console develops a delayed sync pulse (fig 2) for the radar test set group. The target or missile preknock pulse triggers the test delay simulator and establishes time reference for the delayed sync pulse. The delay time is variable and is controlled by a voltage applied to the simulator from the range adjust variable resistor in the test delay control.

SECTION II. MISSILE TRACKING RADAR

12. PURPOSE. The missile tracking radar (MTR) provides a communication link between the computer and the missile.

13. CAPABILITIES. The MTR tracks Nike Ajax and Nike Hercules missiles by an RF signal transmitted from the missile instead of using signal reflection, as in the TTR. A radar beacon transmitter carried by the missile is triggered by the MTR. This beacon transmitter responds by transmitting an RF signal back to the MTR insuring continuous contact with the missile. The MTR then supplies the computer with accurate missile position data. The MTR also codes and transmits steering orders from the computer to the missile and transmits the burst order. Since the Nike Ajax and Nike Hercules missiles have different ranges and different command systems, a Nike Ajax/Hercules switching system is provided to allow the MTR to control either missile from identical computer orders. Although the missile is tracked in the automatic mode, manual and aided modes are provided for test purposes. The MTR requires only one operator, while TTR requires one for each target coordinate.

14. MAJOR UNITS. The eight systems into which the MTR (fig 14) is functionally divided are the command, transmitting, RF and antenna, receiving, ranging, antenna positioning, presentation, and launching positioning.

15. BLOCK DIAGRAM ANALYSIS.

a. Command system. This system (fig 14) converts steering and burst orders from the computer into suitable signals for transmission to the missiles. four pulses in precisely spaced intervals are coded to represent the battery code and the missile steering orders. A fifth pulse is generated to transmit the burst command. These five coded pulses are applied to the transmitter system. The pulsed RF energy from the transmitter is applied through the monopulse duplexer to the missile track antenna reflector assembly and sent to an RF beam to the missile. The missile detects its guidance orders from the spacing of the coded pulses in the RF beam then responds to these orders.

b. Transmitting system. Circuits in the MTR transmitter (fig 15) convert low voltage synchronizing pulses from the command system into high power pulses of RF energy. These pulses are applied to the missile reflector assembly and transmitted to the missile guidance system. The transmitter in the MTR is identical to that of the TTR except for minor differences in the interconnecting wiring. Also in the TTR transmitter, sync pulses trigger the transmitter, while coded pulses trigger the MTR transmitter. The block diagram (fig 15) shows the overall function of the transmitter. Four coded missile sync pulses are applied to the MTR trigger amplifier. These pulses are amplified and shaped into positive trigger pulses for application to the MTR track modulator. The high voltage DC and the sync pulses are applied through the sliprings to the modulator. The sync pulses will fire the track modulator which develops high voltage output pulses. These high voltage pulses are applied to the pulse transformer and the magnetron,

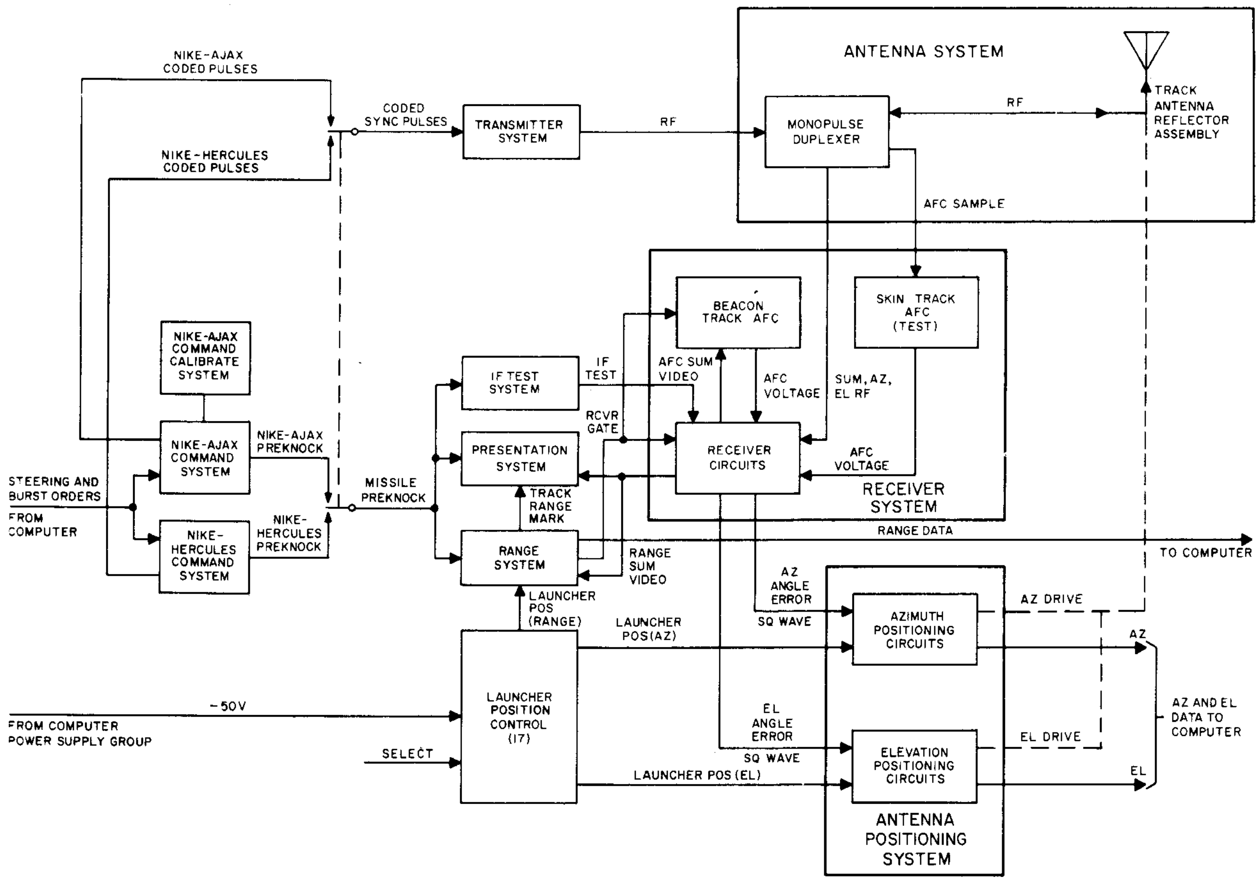

Figure 14. Missile tracking radar - block diagram.

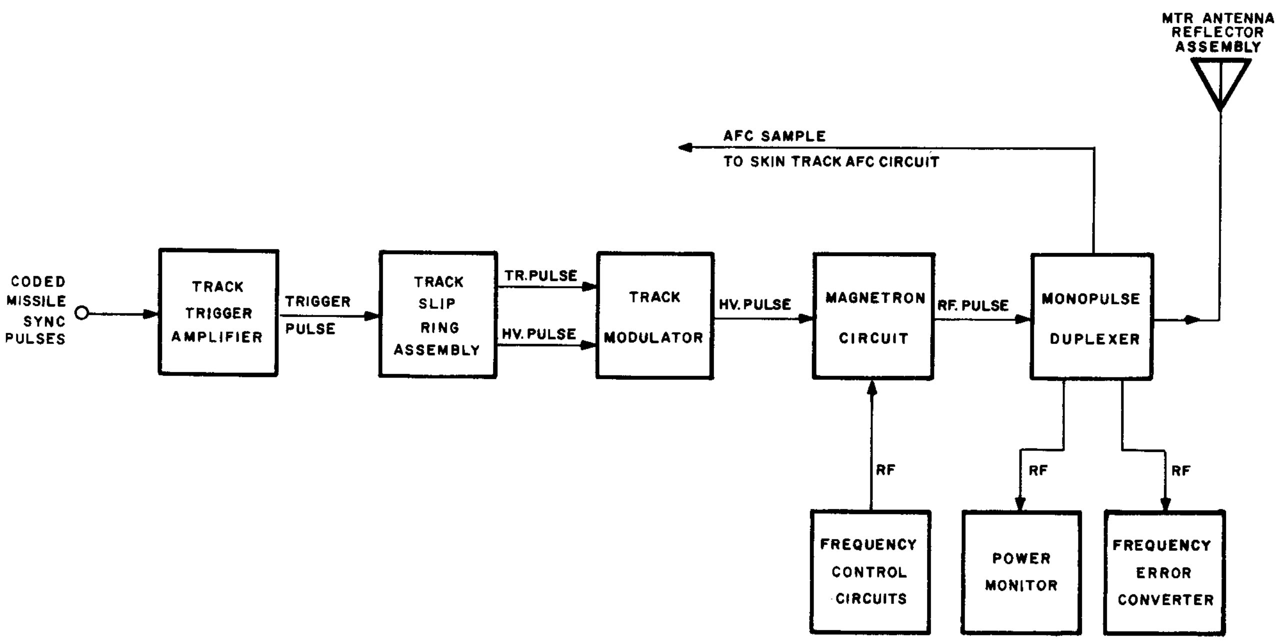

Figure 15. MTR transmitter system - block diagram.

which produce RF pulses within the X-band frequency range. The RF pulses are sent through the monopulse duplexer to the MTR antenna reflector assembly for radiation into space. At the same time, an AFC sample is coupled to the skin track AFC to control the frequency of the local oscillator. An RF signal is sent to the frequency error converter circuit which generates a DC voltage to indicate an "on-frequency" or "off-frequency" condition. A gain meter, in the frequency error converter, provides an indication for adjusting the overall gain of the frequency-error converter so that an "on-frequency" is maintained. The POWER MONITOR measures the average power output of the MTR. Power loss is determined by comparing the loss level with the reference power level established during normal operation. The frequency control circuits are used by the missile track radar operator to control the transmitted RF frequency and contain the following:

(1) A frequency switch which increases or decreases the frequency of the missile track radar transmitter.

(2) A tune-slew switch which selects either the tune (fine) or slew (coarse) mode of the magnetron tuning.

(3) A frequency meter which has two indicating scales. The upper scale is a coarse readout and the lower one is a fine readout of the magnetron frequency.

c. **Antenna.** The RF and antenna system in the MTR is the same as the TTR. For functional description, refer to section I, paragraph 5, of this lesson.

d. **Receiver system.** The MTR and TTR receiver systems (fig 16) are similar. The operation of the track IF attenuator and the track IF amplifiers in the MTR receiver system is identical to that in the TTR receiver. The MTR IF attenuators are used only during acquiring a missile.

(1) The RF beacon response signals from the missile beacon transmitter are received through the missile antenna reflector assembly and channeled through the monopulse duplexer. The sum, azimuth, and elevation RF signals are applied to the missile track amplifier converter which is similar to the TTR. The frequency of the local oscillator in the MTR system is controlled by the beacon track AFC in normal operation and by the skin track AFC during test operation. Outputs from the converter (sum, azimuth, elevation IF's) are applied through the slipring to the IF attenuator (fig 16). The attenuator provides 20-db attenuation and extends the gain control range of the receiver. This attenuator is relay controlled and may be switched out when the received signal drops below a given level as determined by the atten control output of the AGC circuits. An AGC bias is channeled to the IF amplifiers and missile video and switching amplifier. The outputs of the missile video and IF switching amplifier are: range sum video to the range error converter, azimuth and elevation sum IF signals, azimuth and elevation error IF signals to the azimuth and elevation angle error detectors, AFC video to the beacon track AFC, and AGC video to the AGC block where the AGC bias is produced. The AGC bias controls the gain of the receiver system. The sum and error IF signals are used to produce azimuth and elevation angle error square waves which are applied to the MTR antenna positioning system through the error voltage monitor circuit.

(2) The AGC monitor amplifier provides a control for the missile track-indicator when the received signal strength reaches a predetermined level. Before the missile is accepted for firing, the monitor amplifier determines whether the signal strength of the missile beacon transmitter is sufficient for tracking. This evaluation is based on measurement of the AGC level. If the AGC voltage reaches a predetermined value, as set in the AGC monitor amplifier, the missile is automatically accepted. This operation is one of a series occurring in the tactical control circuits which designate a missile as ready for launching.

e. **Ranging system.** The range circuits of the MTR system track the missile in range and provide continuous missile range data to the computer. The normal mode of operation is automatic, although the manual and aided modes are provided for testing procedures. The MTR uses only one low power servoamplifier (auto track) in the range and antenna positioning system. The range system consists of range determination circuits, automatic ranging circuits, and range servo circuits.

(1) The MTR range determination circuit is the same as the TTR circuit (para 8) except that the acquisition track rangemark and the track range gate are not used in the MTR system.

(2) The automatic range circuits consist of the range error converter, the range modulator amplifier, and AGC amplifier. The range sum video signal to the range error converter is derived from the MTR receiver circuits. A coast feature of the range modulator amplifiers allows a 3-second coast interval in the event

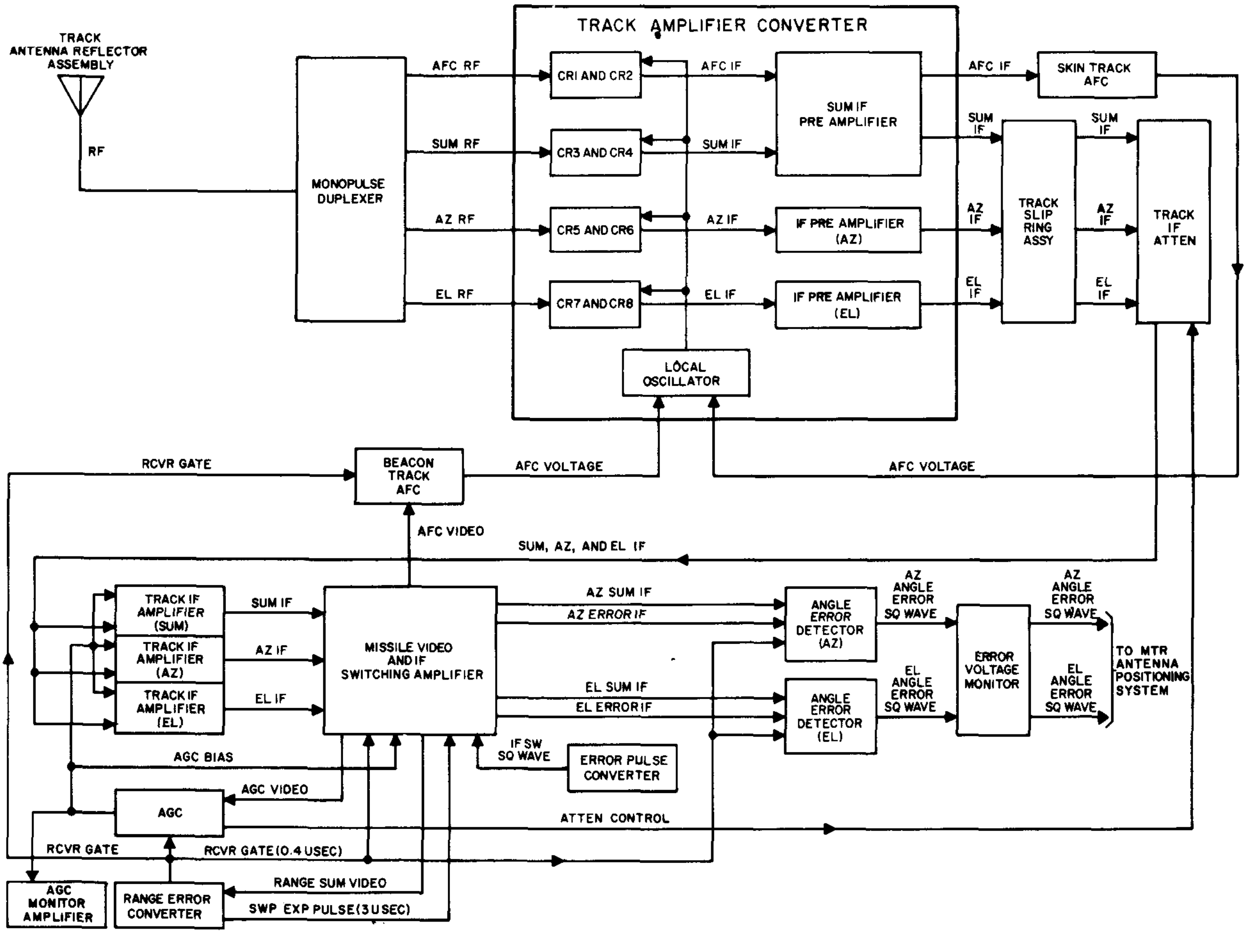

Figure 16. MTR receiver and AFC - block diagram.

the MTR loses contact with the missile. If the missile is not reacquired during the 3-second coast interval, it is given up for lost and the next designated missile is automatically acquired. AGC aids the MTR after it has acquired and locked on a missile.

(3) Range servo circuits automatically slew the MTR to the range of the next designated launcher following an engagement. During test procedures, the servo circuits slew the range in or out in response to range slew. Normal engagement is in automatic, but for testing purposes the manual and aided modes are used.

f. **Antenna positioning system.** The three methods for positioning the antenna are the same as for the TTR. However, acquiring a missile is different from acquiring a target. Three seconds after a missile beacon signal is lost or three-tenths of a second after a burst order is transmitted, the missile antenna is automatically slewed in azimuth to the next designated missile launcher. If the missile is in flight, and auto-tracking is lost for 3 seconds, a fail-safe command occurs and the missile destroys itself.

g. **Presentation system.**

(1) The MTR presentation system (fig 17) contains only circuits for presenting range video. These circuits provide a single sweep trace on the cathode ray tube. This trace contains a movable expanded portion (sweep expansion pulse), a range notch, and the video return. A range indicator dial provides the operator with range information.

(2) The range error converter receives the track rangemark and range sum video and produces the sweep expansion pulse and range sum video and notch. The range sum video and notch are coupled through the coaxial relay to the range track video amplifier. The signal is amplified and applied to the vertical deflection plates of the CRT.

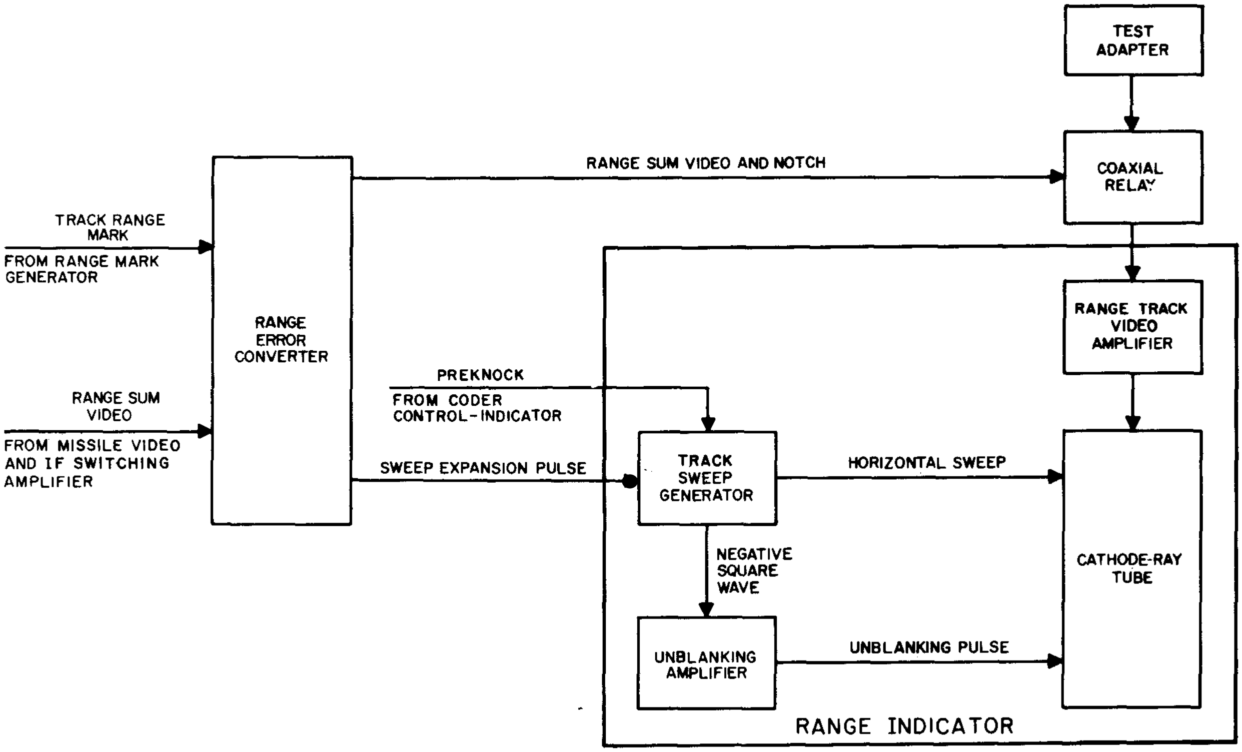

Figure 17. MTR presentation system - block diagram.

(3) The expansion pulse from the range error converter is applied to the track sweep generator, which is triggered by the preknock pulse and provides a horizontal sweep to the CRT and negative square wave to the unblanking amplifier.

(4) The unblanking amplifier applies unblanking pulses to the control grid of the CRT. This insures CRT conduction during sweep time and nonconduction during retrace.

(5) The test adapter, used in conjunction with the range track video amplifier, provides a system test oscilloscope.

h. Launcher position control. There are 17 launcher position controls in the radar set group of the trailer mounted tracking station. Each contains an azimuth and elevation control transformer, a range variable resistor, and an associated relay. Azimuth, elevation, and range coordinates of the flight simulator (test responder) are manually set into one launcher position control while coordinates of the respective launchers are manually set into the other 16 launcher position controls. When the flight simulator is to be used or a missile is selected, three relays (one for each coordinate) in the associated launcher position are energized. Voltages representing preset coordinates are applied to the antenna position circuits and the range circuits. This causes the MTR antenna to slew to the coordinates preset into the preselected launcher position control.

16. RADAR TEST SET GROUP.

a. The radar test set group (fig 18) provides a means for testing the overall performance of the TRR, the TTR, and the MTR systems. The radar test set group (fig 18) consists of: antenna-assembly-mast group, the RF detector, and the radar test set. RF signals are radiated from the antenna assembly mast (fig 18) to the MTR antenna and the TTR in the same manner. These RF signals are used to accomplish certain checks and adjustments. In addition, the radar test set monitors the output power and frequency of the RF pulses transmitted by the MTR and the TTR. The antenna mast (1, fig 18), with the RF detector (2, fig 18) and radar test set cabinet (3, fig 18) mounted at the base, is used for collimation (a process of alining electrical axis of radar antennas). The antenna mast provides a line-of-sight path from the TRR, TTR, and MTR antennas to the tracking and ranging antenna feedhorns on top of

the mast. The antenna mast height allows RF signals to be radiated between the radar antennas and the mast with minimum ground reflection. The RF detector in the radar test set group receives an RF signal from the TRR, but does not transmit to it.

b. The radar test set cabinet (3, fig 18) contains all the circuits for interconnecting the various subassemblies in the radar test set group. The cabinet also has a blower, thermostat, and connectors for connecting cables from the various units. The thermostat controls the cabinet temperature by applying power to the blower for temperature above 65 degrees F and removing the power for temperatures below 45 degrees F.

c. The radar test set pulse generator (fig 19) is triggered by the output pulses from the test delay simulator in the missile radar control console. It produces a short pulse or a long pulse, depending on which mode is being checked. The rectangular pulses from the pulse generator trigger the missile and target oscillators.

d. The missile oscillator (fig 19) generates an RF pulse at a PRF which is controlled from the MTR system. The frequency of the missile oscillator RF output pulses is variable in power and range to simulate missile beacon response signals. They are used to check out the MTR system in remote control.

(1) The missile oscillator is a reflex klystron consisting of an electron gun that produces an electron beam of uniform velocity, a tunable cavity resonator, and a repeller electrode. By varying either cavity size or repeller voltage, the frequency of the output RF may be changed.

(2) The target-standby-missile switch S1 (fig 19) permits the radar test set group to be used with the TTR or MTR system. In the position shown (target position), 120 VAC is supplied through S1C to range slew switches S1 (target) and S2 (missile) to the test delay control. This 120 VAC drives a motor which adjusts a delay pulse to simulate range variations caused by an actual missile or target. Signal level control transformers B1, on the missile radar control and target radar control consoles, are part of a servosystem which adjusts the amount of RF signal passing through the test set subassembly by varying the amount of attenuation produced by AT4.

e. The target oscillator generates pulsed RF signals that test the TTR system. The operation is the same as the missile oscillator operation except that the output pulse width is controlled by a short pulse or a long pulse. The frequency of the target oscillator can be changed at the target radar control console in the trailer mounted tracking station by B2 (control transmitter) or at the radar test set by B3 (differential transmitter).

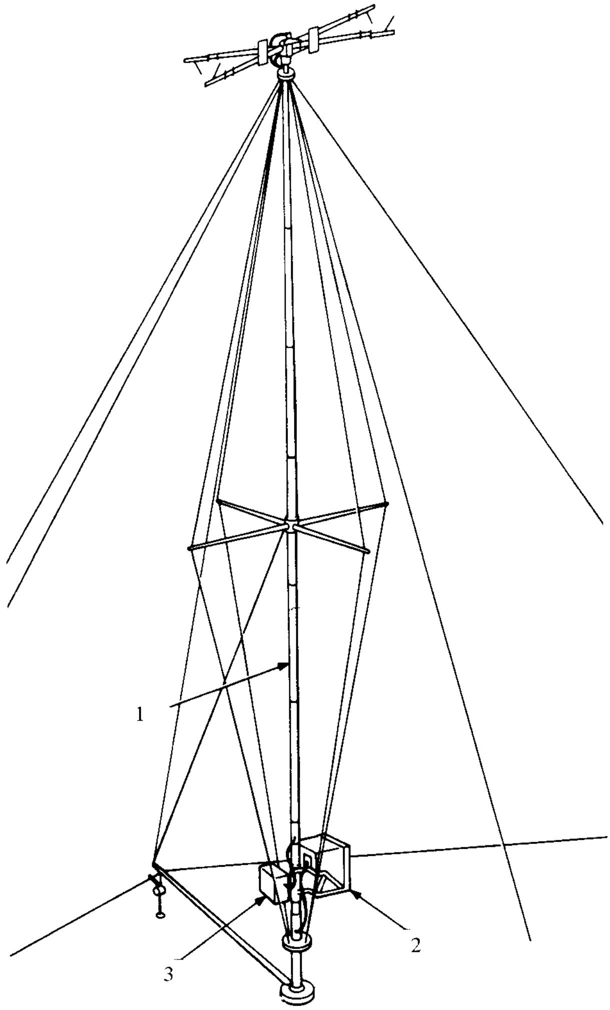

Figure 18. Radar test set group - overall view.

f. The test set subassembly provides the microwave signal path from the missile and target oscillators to the RF power meter and the tracking antenna horn.

g. The RF power meter measures the power generated by the missile and target oscillators in the radar test set and the power received from the MTR and TTR antennas. The RF power meter contains a frequency measuring cavity that measures the frequency

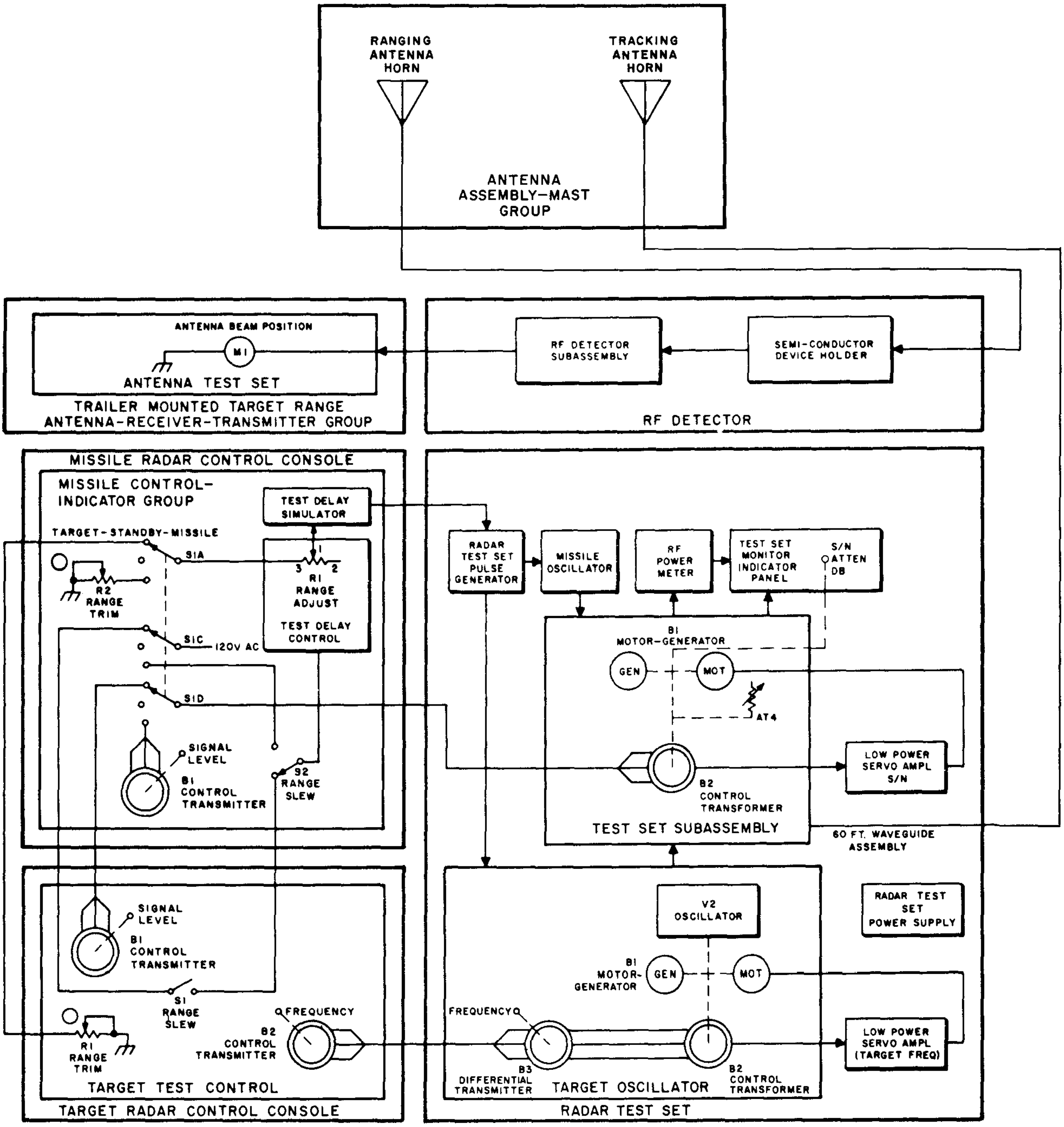

Figure 19. Radar test set group - functional block diagram.

of these signals and a bridge circuit to measure the power.

h. Test set monitor indicator panel (fig 19) is a mounting which houses a video connector for pulse monitoring, the S/N ATTEN-DB knob, and an RF-POWER-DB meter and the shaft which controls attenuator AT4.

i. There are two low power servoamplifiers (LPSA) in the radar test set, one for each servosystem. The LPSA receives a 400-hertz control voltage which drives the servomotor and its associated components.

j. The power supply provides a regulated 300 VDC and 6.3 VAC for the electron tube circuits in the RF test set group. A 300-volt supply gives the plate and cavity voltages while a regulated -250-volt DC provides repeller voltages for the RF oscillators and biasing voltages for the electron tube circuits. The 6.3 VAC

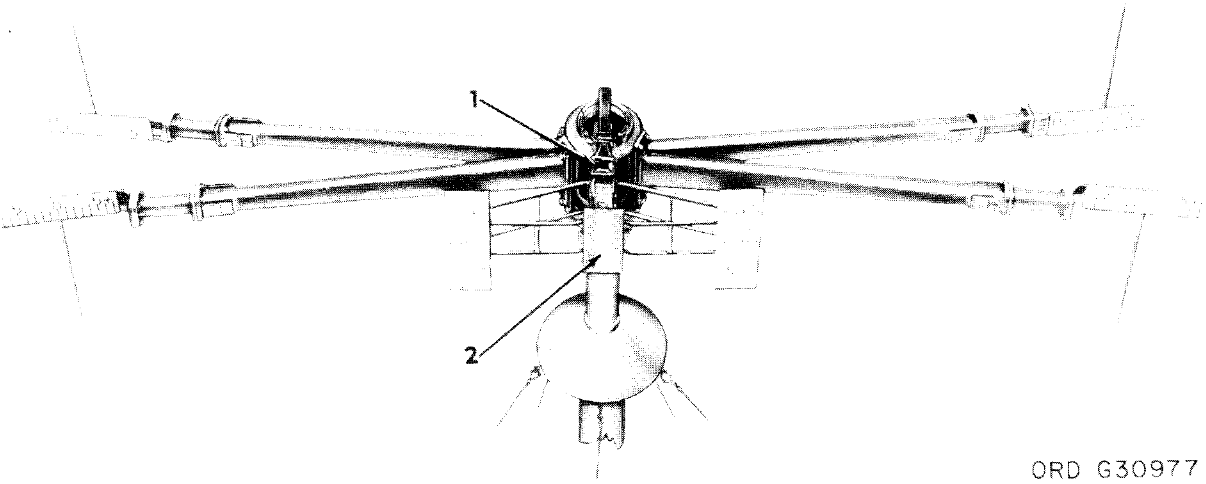

Figure 20. Antenna assembly - mast group.

supplies filaments for tubes and indicator lights on the RF test set.

k. The antenna group includes the radiating and receiving antenna elements of the radar test set group. Both systems are mounted on the same antenna mast (fig 20). The missile and target oscillators transmit from the tracking antenna horn (2, fig 20), while the ranging antenna horn (1, fig 20) is used for receiving only. The 60-foot mast prevents excessive radar ground reflections and provides an unobstructed path between the MTR, TTR, and TRR antennas and the antenna assembly-mast horns.

l. The radar test set group receives signals from the TRR but does not transmit to it. The RF pulses transmitted by the TRR are intercepted by the ranging antenna horn (1, fig 20) and travel down the waveguide to the semiconductor device holder (fig 19) where the signal is attenuated by a variable attenuator and coupled to a crystal detector. The detected signal is amplified in the RF detector subassembly. The output from the RF detector is applied to ANTENNA BEAM POSITION meter M1 on the antenna test set. The antenna test set positions the TRR antenna for maximum deflection. The TRR antenna test set, in conjunction with meter M1, positions the TRR antenna and determines the half-power points and symmetry of the radar beam.

EXERCISES FOR LESSON 4

1. Where is the ANTENNA BEAM POSITION meter M1 located?

   A. TTR trailer and antenna group
   B. MTR trailer and antenna group
   C. TRR antenna group
   D. Antenna test set

2. What is the output frequency of the target range modulator amplifier in the ranging unit of the TTR?

   A. 400 hertz
   B. 82 kilohertz
   C. 60 megahertz
   D. 800 to 900 megahertz

3. To which unit is the output of the TTR trigger amplifier applied?

   A. Modulator
   B. Converter
   C. Synchronizer
   D. Local oscillator

4. In what frequency band does the TTR operate?

   A. Ku
   B. L
   C. X
   D. S

5. What is the purpose of the target azimuth coupling resistor assembly in the TTR antenna positioning system?

   A. Develop azimuth signals
   B. Impedance matching
   C. Dropping resistor
   D. Stability

6. What type of waveguide junction is used to form the monopulse duplexer in the TTR transmitter system?

   A. E
   B. H
   C. T
   D. Hybrid tee

7. What type of reflector is used with TTR antenna?

   A. Orange peel
   B. Parabolic
   C. Disc
   D. Lens

8. What component in the target radar control console is used to adjust the frequency of the radar test set target oscillator?

   A. Differential transmitter (B_3)
   B. Control transmitter (B_2)
   C. Range trim (R_1)
   D. Signal level (B_1)

9. How many high power servoamplifiers are used in the antenna positioning system in TTR?

   A. 8
   B. 6
   C. 4
   D. 2

10. Which signal allows time sharing the upper and lower traces on the TTR presentation system indicators?

    A. Target preknock
    B. Vertical spacing square wave
    C. Sweep expansion pulse
    D. Range sum video and notch

11. The MTR antenna position data supplied to the computer is:

    A. D_M, R_M, T.
    B. D_M, A_M, E_M.
    C. R_T, D_M, X_M.
    D. H_M, V_M, V_C.

12. What is the purpose of the TTR angle error detectors?

    A. Develop AFC signals
    B. Develop AGC signals
    C. Develop antenna pointing error signals
    D. Provide range and azimuth position information

13. Where is the RF pulse produced in the MTR system?

A. Frequency error converter
B. Magnetron circuit
C. Track modulator
D. Track trigger amplifier

14. What is the time interval, in seconds, of the MTR range modulator amplifier coast feature?

A. 3
B. 2
C. 0.3
D. 0.1

15. What is the reason for using an unblanking amplifier in each of the A scope indicators in the TTR presentation system?

A. To display only the desired information
B. To display only one target at a time
C. To blank out the beam retrace
D. To allow the CRT to conduct during retrace

16. How many low power servoamplifiers are used in the MTR ranging system?

A. 1
B. 2
C. 3
D. 4

17. What is the purpose of the TTR?

A. Supply continuous target position data to the computer
B. Supply range of the target to the computer
C. Supply acquisition radar target information
D. Supply MTR with target information

18. What is (are) the output(s) of the converter assembly in the TTR receiver system?

A. Receiver range gate
B. Expansion pulse
C. Sum, video pulse, and expansion pulse
D. Sum, azimuth, elevation, IF signals

19. By what means does the MTR control the missile after launch?

A. Coded RF beam
B. CW transmission
C. Varying DC voltages
D. Negative pulse

20. What is the function of the intermediate drive control in the TTR antenna positioning circuits?

A. Provide an impedance match
B. Attenuate high power signals
C. Shape the range error pulses
D. Provide 400-Hz voltage and stability

21. What is the primary purpose of the TR and ATR tubes in the TTR transmitter system?

A. Provide switching
B. Protect receiver crystal
C. Concentrate returned energy
D. Reject unwanted signals

22. What type of signal does MTR receive from the missile?

A. Surface echo
B. Doppler
C. Frequency modulated
D. Missile beacon

23. What is the purpose of the skin track AFC of the TTR?

A. Test purposes only
B. Keep the transmitter operating at a fixed frequency
C. Keep the local oscillator operating at a frequency 60 megahertz above the transmitted frequency
D. Keep the received signals at the same level and frequency

24. What unit, or units, extend(s) the gain control range of the MTR receiver?

A. IF main amplifiers
B. IF preamplifiers
C. Range error converter
D. Attenuator

25. What component is protected by the TR tubes in the TTR?

A. Crystals
B. Shutters
C. AGC unit
D. Attenuator

26. What junctions of the monopulse duplexer develop the sum signal in the TTR system?

A. T_1, T_3, and T_4
B. T_1, T_2, and T_3
C. T_1, T_2, and T_4
D. T_2, T_3, and T_4

27. What is collimation?

A. Alinement of mechanical axis
B. Alinement of electrical axis
C. Alinement of optical axis
D. Alinement of trunnion

28. What will be the AFC mode of operation of the TTR if the AFC IF is 65 megahertz?

A. Skin track
B. Beacon track
C. Search
D. Hunt

29. The skin track AFC circuit in the MTR is used for what purpose?

A. To track the missile
B. To aid the presentation
C. For testing and calibrating
D. For calibrating and manual tracking

30. How many channels does the video time share amplifier in the TTR presentation system have?

A. 1
B. 2
C. 3
D. 4